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Ceramic Abstracts and the Bulletin

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POTTERY BODY SPAR

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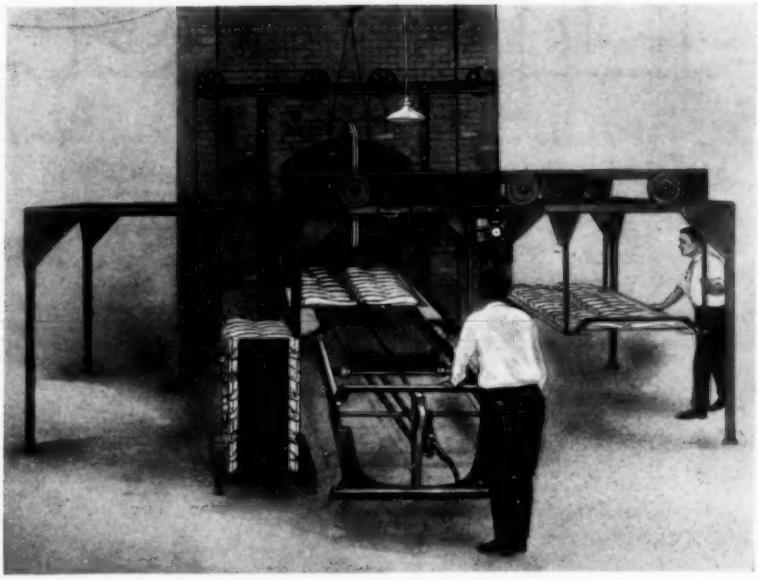

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ORIGINAL PAPERS

THE RELATIVE ACTION OF ACIDS ON ENAMEL—V[1]

BY EMERSON P. POSTE

ABSTRACT

The work of the former Committee on Standardization of Tests is the starting point for the work covered in this paper. The action of citric acid on different types of enamels is studied. The time required to produce first etching of cooking ware enamels with 15% acid is investigated. The above lead to the conclusion that commercial cooking ware enamels as a whole are readily etched by 15% citric acid and the degree of etching is not necessarily proportional to the time of action. The use of 1% acetic acid and also the use of a "spot" test are investigated, including tests on commercial ware. The work as a whole brings out certain weaknesses of the possible methods of testing but does not result in the establishment of a satisfactory test.

Introduction

Previous volumes of the *Journal*[2] contain records of work done towards the establishing of a reliable quantitative test for the acid resistance of enamels. The importance of a standard solution easily made without the use of laboratory facilities was brought out and a solution of 6 ounces of citric acid in one quart of water was selected as a possible standard. It was shown that the slight variations in strength which might come in

[1] Presented before the Enamel Division, Pittsburgh Meeting, February, 1923.

[2] E. P. Poste, "The Relative Action of Acids on Enamel, III," *Jour. Amer. Ceram. Soc.*, **2** [1], 32–43(1919); *ibid.*, IV, **3** [7], 560–7 (1920).

with solutions made by the average druggist were of negligible amount in terms of action on enamel. Efforts to determine definitely the amount of action on an enamel surface included the possible staining of the etched surface by an organic dye and the possible use of lamp black-vaseline smear as an indicator.

During the past year efforts have been made to determine whether the former ideas could be brought to a successful conclusion and the burden of the present record is the information bearing on this point together with data regarding certain other proposed tests which came to the attention of the Committee.

Further Work on Citric Acid

The former work on citric acid had involved a rather limited number of enamels. The question arose as to whether all enamels would have the same general characteristics in terms of resistance to citric acid. To determine this point frit tests[1] were run on three enamels in addition to those previously reported.[2] The results can be easily noted by reference to Fig. 1. The curves "White—IV–A–1" and "White—IV–A–2" are reproduced from the previous record[2] as a matter of comparison. The frits involved were commercial white ware materials, representing two different formulae. The three additional enamels tested were a "one coat gray," "white" and "ground" with results as shown. The curves suggest that citric acid has the same general characteristic action on the various types of frit.

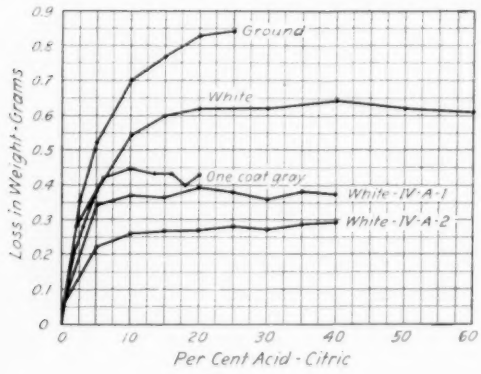


FIG. 1.

The curves showing higher acid losses seem to break at higher acid concentrations. This may be partially due to depletion of acid in the solution—this test is not recommended for two-gram samples and 100 cc. of solution in cases where the loss in weight goes much above 0.5 gram. In such cases the amount of solution should be increased or the weight of sample decreased.

The second point to be investigated was with reference to the time required to produce first etching using the black smear as an indicator. This can be best presented by quoting from one of the reports covering an actual test.

[1] *Trans. Amer. Ceram. Soc.*, **17**, 138 (1915).

[2] E. P. Poste, *Jour. Amer. Ceram. Soc.*, **3** [7], 561 (1920).

The following plan was adopted for showing the effects of different times of action on a single piece of ware. Taking a pan of about one quart capacity, 100 cc. of the acid solution were placed in the dish and allowed to stand one hour. At that time 100 cc. more were added and the same continued at intervals of 90, 105, 112 and 116 minutes. At 120 minutes the solution was poured out and the dish rinsed. When dry the successive rings of etching from top down showed the effect of 4, 8, 15, 30, 60, and 120 minutes action.....

Samples of eight different makes of white ware were tested in this manner with 15% citric acid at room temperature, 80–90°F. These included a very highly resistant white and a very soft white..... All were examined after streaking with a mixture of lamp black and vaseline. The results of the observations are as follows:

No. 1—No visible action after two hours.

No. 2—Same, but shows slight action on small parallel patches about one-half inch long and one-sixteenth inch wide after two hours.

No. 3—Etching was visible in four minutes. After two hours the etching was not strong and the gloss was not lost.

No. 4—Etching was visible in eight minutes. After two hours the etching was not serious.

No. 5—Shows etching in four minutes. Not bad in two hours but worse than No. 3.

No. 6—A German ware. About the same as No. 3.

No. 7—Etched strongly in four minutes.

No. 8—Etched strongly in four minutes. Disintegrated in two hours. Shows etching where solution was poured out, not in contact more than one second.

In commenting on the above the member of the present committee doing this work says:

From the above it appears.....that it is not practical to base a test on the time required for the first appearance of etching since the latter is not related to the extent of etching on longer treatment. Two hours' treatment serves to differentiate sharply between the different grades of enamel by direct comparison one with the other.[1]

Further work along this line was done using two commercial enamels designed for two classes of work; the first for the dairy trade, the most severe acid condition involved being about one per cent lactic, the second for the canning trade involving a large variety of combinations of organic acids at rather low concentrations. Both enamels are commercially successful in the respective fields. Using 15% citric acid at room temperatures an exposure of one hour for the dairy enamel produced an etching visible without the use of the smear, while a half hour exposure produced practically as severe results. The canning enamel gave an etching on 17-hour exposure that was visible without the smear, on one hour an etching not seen by the unaided eye but easily seen by aid of the smear, and a slight etching as indicated by the smear on one-half hour exposure.

From these and other studies it became evident that citric acid of the chosen strength would throw out enamels known to be satisfactory for

[1] H. F. Staley, "Some Relations of Composition to Solubility of Enamels in Acids," *Jour. Amer. Ceram. Soc.*, **4** [9], 711 (1921).

kitchen use if the first appearance of etching as detected by the smear was to be taken as the basis of judgment. It was also evident that etching as detected by this method was not proportional to time of exposure.

Proposed Bureau of Standards Test

At this particular juncture the attention of the Committee was called to the tentative test which had been recently suggested by the Bureau of Standards. This test is essentially as follows:—

> A solution of one per cent glacial acetic acid and 99% distilled water by volume and at a temperature of 60° to 70°F is placed in the article and removed hourly. The piece is examined for loss of gloss or etching—either of which is considered as indicating failure of the enamel.

In studying the tentative test of the Bureau of Standards with reference to a standard test for the SOCIETY the Committee considered several points. The first was that of the reliability of the proposed solution with reference to strength.

One Per Cent Acetic Acid as a Standard Solution

It was anticipated that the stock of glacial acetic acid that might be found on the average drug store shelf would vary in strength, and that the average druggist might have some difficulty in making up a solution of exactly the desired strength. To determine these points samples of glacial acetic acid obtained from three drug stores were analyzed, as well as acid from a stock bottle in the laboratory. Dilute solutions were also made up in accordance with the specifications of the test. In the Labo-

ACCURACY OF "1% BY VOLUME GLACIAL ACETIC ACID SOLUTION"

Source of acid	Per cent by weight stock	Per cent by weight dilute	Remarks
A	99.1	1.13	Rough method
		1.06	Accurate method
B	100.0	0.82	Glass stoppered bottle
C	100.0	0.33	Glass stoppered bottle
D	97.1	0.88	Cork stoppered bottle
E	99.0	1.05	

A—Laboratory stock.
B, C, D—Local drug stores.
E—To be expected from U. S. P. specifications.

ratory two methods were followed: one using ordinary graduated cylinders, the other using a volumetric flask and dispensing the acid from a burette. The effort was made to get samples from five stores. Two of these did not have glacial acetic acid. One of the druggists furnishing solution did not seem to know how to go about the dilution of the acid. The results of these efforts in terms of content of acetic acid by weight are given in

the preceding table. It should be kept in mind that the U. S. P. specifications for glacial acetic acid state that it is "a liquid containing not less than 99% of $C_2H_4O_2$ or CH_3COOH." It further states that it should be kept in a glass stoppered bottle. On the basis of a 99% solution by weight as the starting point a 1% solution by volume should contain 1.05% by weight.

From the above it seems that it might be difficult for the enameler not having laboratory service available to get, under the given specifications, acid of accurate strength.

The next point to be investigated was the seriousness of the above irregularities in the strength of acetic acid in terms of action on enamel. A series of frit tests was run using an enamel considered reasonably similar in acid resistance to the average cooking ware grade. The results are seen in Fig. 2. At "A" is indicated the action of a 1% solution, and at "B," "C" and "D" the action of the corresponding strengths as shown in the Table. It may be concluded that variations of 1/4% in either direction would not have a serious effect on this particular frit. But it is possible that the break in the curve would come at some other point with other enamels, in which case a solution of .75% strength might give quite different results from a solution of 1.0% strength. It is obvious that the error involved in "C" is unreasonable. It certainly is serious enough to affect materially the rate of action.

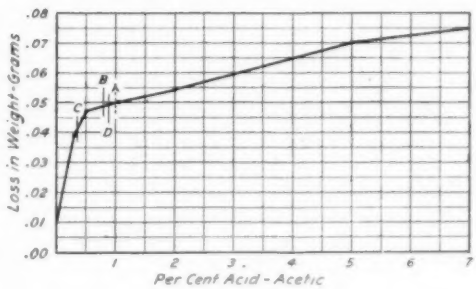


FIG. 2.

With further reference to the choice of an acid another line was followed out. It had been concluded that 15% citric acid was too strong but that citric could be made up to accurate strength by the average druggist. It was also evident that 1% acetic was of about the proper strength but was possibly subject to serious irregularities in strength as made up by the druggist. How about a citric solution of the same rate of action on enamel as 1% acetic? To throw light on this point a series of frit tests was run using weak citric solutions on the same frit involved in Fig. 2. It was concluded from this that 0.15% citric has about the same rate of action as 1% acetic. The use of this acid will be discussed later.

Spot Test

Another method of testing came to the notice of the Committee. It was referred to as a "one minute spot test" and was described as follows:

.....place a drop of the acid solution on a horizontal surface of the piece, allow it to remain one minute, then wipe with a damp sponge and rub lightly with a dry towel. If the enamel has been acted upon a reduction in specular reflection is easily observed at the spot where the acid was applied. By this test 1% citric acid affects most of the enameled cooking utensils on the market and even 1% acetic acid shows slight diminution in specular reflection on some of the high priced ware. This test can be made approximately quantitative by determining the strength of acid which will just affect the surface of the enamel. For a simple test to be used outside the laboratory for acceptance or rejection of ware, a standard strength acid can be used but it will be necessary to decide upon a low percentage if rejection of most of the ware on the market is to be avoided.

Tests of Commercial Ware

As a matter of comparison of the above three methods of testing a number of representative pieces of commercial ware were obtained from local stores. They were as follows:—

No. 1—Good looking white inside and out.
No. 2—Good looking white inside and out.
No. 3—Good looking white inside and out.
No. 4—Fair white inside, mottled blue outside.
No. 5—Poor white inside, mottled blue outside.
No. 6—Fair white inside, mottled blue outside.
No. 7—Light blue inside and out.
No. 8—Mottled brown and white.
No. 9—Good granite.
No. 10—Poor granite.
No. 11—Fair granite.

The three methods of testing were designated by letter as follows.

A—1% acetic acid—1½ hours.
B—0.15% citric acid—1½ hours.
C—One minute spot test.

In the testing, the dishes were tipped differently in A and B so as to keep the areas in contact with acid separate, also saving unexposed areas for use in C.

After exposure to the acetic acid the surfaces were cleaned and examined visually. In general they were as follows:

No. 1—Very definite action.
No. 2—About like 1.
No. 3—Possibly a little worse than 1 and 2.
No. 4—About like 1 and 2.
No. 5—About like 1 and 2.
No. 6—Definite action but not as bad as 1 and 2.
No. 7—About like 6.
No. 8—No visible action.
No. 9—Very slight action.
No. 10—Slight action but more definite than 9.
No. 11—Edge of exposed area could be faintly seen but no actual loss of gloss could be noted.

Three different persons were asked to place the various pieces in their order of decreasing acid resistance. The results were as follows:

White Inside 6–5–4–2–1–3
6–5–1–3–4–2 Average 6–5–1–(4–2)–3
6–5–2–1–4–3

Colored 8–7–11–9–10
8–11–9–10–7 Average 8–11–7–9–10
8–11–7–9–10

Entire Lot 8–6–11–7–9–5–10–4–2–1–3
8–11–9–6–7–10–5–4–1–3–2 Average 8–11–(6–7–9)–10–5–4–2–1–3
8–11–7–9–10–6–5–2–4–1–3

In like manner the dishes were tested with the 0.15% citric acid. In general the action of the citric had been more severe than the previous acetic. The observations were as follows:

No. 1—Gloss nearly gone.
No. 2—Dull. Gloss practically gone.
No. 3—Dull.
No. 4—Dull.
No. 5—Gloss nearly gone.
No. 6—Very slight action.
No. 7—Very marked action. Very dull.
No. 8—Trace of action. Less than No. 6.
No. 9—Definite action. Still somewhat glossy.
No. 10—Dull.
No. 11—Gloss partly gone.

The pieces were placed in order of decreasing acid resistance by three parties as before with the following results:

White Inside 6–5–1–4–2–3
6–5–4–2–1–3 Average 6–5–4–1–2–3
6–5–4–1–2–3

Colored 8–9–11–7–10
8–9–11–7–10 Average 8–9–11–7–10
8–11–9–7–10

Entire Lot 8–6–11–9–5–2–1–4–7–10–3
8–9–11–6–5–4–7–10–2–1–3 Average 8–6–11–9–5–7–4–(10–2)–1–3
8–6–11–9–7–5–10–4–1–2–3

The spot test was applied to the sample pieces of ware using two different acids: 1% acetic, and 1% citric. The results were judged in terms of four classifications—no spot, slight spot, definite spot and dull spot. The slight spots could only be seen under the best of reflected light; the definite spots without particular effort and the dull spots without the use of strong reflected light at all. The results are tabulated:

Number	1% Citric	1% Acetic
1	Dull	No
2	Slight	No
3	Definite	No
4	Slight	No
5	Definite	Slight
6	Slight	No
7	Definite	No
8	No	No
9	No	No
10	No	No
11	Slight	No

Classification in terms of decreasing acid resistance as suggested by this test results as follows:

(8–9–10)–(2–4–6–11)–(3–5–7)–1

As a matter of comparison the various sets of classifications will be presented together:

1% acetic acid—8–11–(6–7–9)–10–5–4–2–1–3
.15% citric—8–6–11–9–5–7–4(10–2)–1–3
1% citric spot—(8–9–10)–(2–4–6–11)–(3–5–7)–1

These three tests agree in designating No. 8 as the best enamel as to acid resistance, although in the spot test two other enamels were classed with it which were not next to it in the other tests. The first two tests agree in allowing No. 8 to pass, and placing next or near to it the same numbers. They also agree in naming No. 3 as the poorest with numbers 1 and 2 next in order. The other samples vary in exact order but appear in the same general grouping in both cases.

With reference to the effort to substitute 0.15% citric acid for 1% by volume acetic it has been noted that in the above tests on commercial ware the citric acid acted more severely than the acetic, though the relative action on the different enamels was in about the same order. Although citric acid is more uniform as found in stock there would be definite objections to depending on a solution as weak as or weaker than 0.15% as a standard solution. Slight errors here would make marked differences in rate of action as the curve of action against concentration is very steep at this point. The amount of acid involved in making up relatively small batches of acid would be small and subject to error. So the work done would not seem to vindicate as a substitute for 1% acetic acid, citric acid of the same rate of action on enamel. It would probably result in less error to use the 1% acetic taking special precautions to see that it was made up accurately from stock of the proper composition.

Summary

In thus rather roughly reviewing the work of the Committee we have placed on record various points that may add to the general knowledge

regarding the action of acids on enamel. We have brought out further information with reference to the action of citric acid on different enamels. Previous investigators have been checked in their findings that acid action on enamel surfaces is not necessarily proportional to time and this suggested in this case the present impracticability of attempting to make use of a definite quantitative basis for acid action. We have reviewed the Bureau of Standards tentative test and while we have found certain points of criticism with regard to the acid named therein, we have failed to arrive at a satisfactory substitute. We have further carried out certain tests on commercial ware including a spot test that, without doubt, would be of value as a means of quick results in the hands of one experienced in its use.

NOTE: We wish to acknowledge the hearty coöperation of the members of the Committee, R. D. Cooke, H. N. Cox and L. J. Frost, for the part they have had in the experimental work and suggestions in regard thereto.

DIRECTOR OF LABORATORIES
THE ELYRIA ENAMELED PRODUCTS CO.
ELYRIA, OHIO

A RAPID MEANS FOR THE DETERMINATION OF QUARTZ CONTENT OF FELDSPAR[1]

By M. C. Booze and A. A. Klein

ABSTRACT

The quartz content is determined by making a rapid fusion of the feldspar without dissolving an appreciable amount of the quartz, crushing the fused mass, immersing a portion of it in a liquid of the proper index of refraction and comparing the visible quartz with standard samples containing known quantities of quartz. A difference of 5 per cent in quartz content can readily be detected. The fusion and optical examination can be made in two hours and does not require a knowledge of microscopy.

The commercial grades of feldspar as milled by practically all producers today contain considerable quantities of quartz. The removal of even a large part of the quartz is so difficult that we cannot expect to obtain a product with less than 10% present and in many cases the content will be as high as 30 or 35%.

This condition has probably been reached in recent years, the producer having worked out his purer deposits and is now being forced to turn to the more impure ones. Except in rare cases the quartz crystals are so intermingled with those of feldspar that complete removal of the former is practically impossible.

The determination of the quartz content by chemical analysis requires too much time to be practical where it is desirable to test shipments before unloading and is only satisfactory where decomposition products or accessory minerals other than quartz are absent.

The effect of the quartz is largely to dilute the feldspar. While it does affect the softening point, a softening point determination is not sufficiently accurate for the determination of the amount of quartz present nor the variation in amount between shipments.

Since feldspar is largely used in ceramic bodies to which free silica is intentionally added, the presence of quartz is usually not objectionable. The variation in quartz content, however, is equivalent to changes in composition of the body and so should be avoided.

The method which has been devised for the determination of the amount of quartz depends, for its success, upon the difference in optical properties between feldspar glass, and quartz. The optical constants of the crystalline alkali feldspars and quartz may be so alike that the two are difficult of quantitative separation microscopically. Since there is a considerable difference between the temperatures at which feldspar and quartz lose their crystallinity, it is easily possible to fuse the one without affecting the physical state of the other. When this is accomplished it becomes an easy matter to distinguish between them microscopically.

[1] Presented before the Whiteware Division, Pittsburgh Meeting, February, 1923.

In the practical application of the method therefore, a sample of the feldspar containing quartz is heated rapidly to a point where the feldspar becomes a glass without appreciably affecting the quartz either by fusion or by solution. The fusion when cold is crushed and a portion of the powder immersed in a liquid or resin of the proper index of refraction, *e. g.*, clove oil, ethylene bromide or Canada balsam and an estimate made of the relative amounts of feldspar glass and quartz.

In order that more accurate determinations might be made, a quantity of pure feldspar was obtained by careful selection and fusions were made of mixtures of this feldspar, with known quantities of quartz. By comparison with the known samples the quantities of quartz in unknown samples may be readily and accurately determined.

In the successful application of this method it is of course necessary to completely fuse the feldspar without dissolving an appreciable quantity of quartz. Time required for the test is also an important factor where tests are run on incoming shipments. To determine the limits for the proper heat treatment, fusions were made at cones 9, 10, 11 and 12, each being made in a pot furnace using city gas and air at 12 pounds pressure. The interior diameter of the furnace was approximately 8″ x 10″ high. In some cases the fusions were in the shape of standard cones and in other cases were made in alundum crucibles approximately 1 inch in diameter by $1^1/_2$ inches high.

The data on these runs are as follows:

Cone 9 tip touching cone 10 started in 2-hour burn with no soak. New Hampshire feldspar contained 10 to 15% of crystalline feldspar. Maine feldspar also indicated considerable quantities of unmelted feldspar. In neither case was there a noticeable amount of quartz solution.

Index of refraction of glass from New Hampshire feldspar = 1.486 ± .001.

Index of refraction of glass from Maine feldspar = 1.488 ± .001.

Cone 9 tip touching in $1^1/_4$ hours with a 15-minute soak. New Hampshire feldspar indicated 10% of quartz with no quartz solution. From 3 to 5% of crystalline feldspar was present. Maine feldspar indicated 30% of quartz. About 5% of crystalline feldspar was present.

Cone 10 tip touching in $1^3/_4$ hours with a 15-minute soak. New Hampshire feldspar showed a trace of crystalline feldspar but there was none evident in Maine feldspar. There was no evidence of quartz solution.

Index of refraction of glass from New Hampshire feldspar = 1.486 ± .001.

Index of refraction of glass from Maine feldspar = 1.488 ± .001.

Cone 11 tip touching in $1^1/_2$ hours and soaked for 15 minutes. There was no crystalline feldspar present in either the New Hampshire or Maine samples nor a noticeable amount of quartz solution.

Index of refraction of glass from New Hampshire feldspar = 1.486 ± .001.

Index of refraction of glass from Maine feldspar = 1.488 ± .001.

Cone 11 tip touching in $1^1/_2$ hours and soaked for 30 minutes. The data here were the same as in the previous run, there being no measurable quartz solution from the longer soak.

Index of refraction of glass from New Hampshire feldspar = 1.486 ± .001.
Index of refraction of glass from Maine feldspar = 1.488 ± .001.

Cone 12 tip touching in 1¾ hours and soaked for 15 minutes. The data here indicated no more quartz solution than for the lower heat treatments. There was no crystalline feldspar present in either case.

Index of refraction of glass from New Hampshire feldspar = 1.486 ± .001.
Index of refraction of glass from Maine feldspar = 1.488 ± .001.

It is evident that cone 11 is the minimum for bringing about complete fusion in a heat treatment of approximately two hours. The length of soak determines the completeness of the fusion as does also the size of the sample. Crystalline feldspar has been observed when cone 12 was put down flat in one hour with no soak. A crucible larger than 1 inch to 1¼ inches in diameter should not be used and the amount of charge should not be over 20 grams. A heat treatment corresponding to cone 12, down in 1½ hours, with a 15-minute soak is recommended as being the least liable to give erroneous results.

This heat treatment will suffice for a feldspar high in potash as well as one containing approximately equal percentages of potash and soda.

The following analyses give the compositions of the Maine and New Hampshire feldspar used, the former indicating 30% of quartz and the latter 10% by the method of fusion and microscopic examination:

	Al_2O_3	Fe_2O_3	SiO_2	TiO_2	CaO	MgO	Loss on ignition	Na_2O	K_2O	Total
New Hampshire	17.33	Trace	66.69	Trace	Trace	None	0.21	2.98	12.01	99.22
Maine	15.23	0.33	73.50	0.03	0.37	None	0.53	4.45	4.75	99.19

As stated above the success of the test depends upon the fact that the alkali feldspars upon being heated sufficiently to become a glass do not return readily to their original crystalline state. The fusion takes place at a heat treatment which is too low to permit of any solution of quartz in the feldspar glass, as indicated by Klein.[1]

Obviously the distinction between isotropic feldspar glass and crystalline quartz is easily accomplished with the polarizing microscope since with polarized light and crossed nicols the former appears black opaque and the latter shows interference colors.

The test is carried out as follows: The fused product is pulverized and the powder passed through small screens clothed with No. 10 and No. 21 standard silk cloth, the product passing through the No. 10 and retained on No. 21 being tested. The 100- and 200-mesh standard cement screens can be substituted. This operation is done merely to provide a convenient and fairly uniform grain size for examination at a magnification of about 100 diameters.

[1] "Constitution and Microstructure of Porcelain," Bur. of Standards, *Tech. Paper* **80**, p. 13.

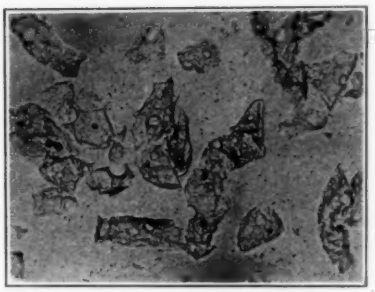


FIG. 1.—Showing grains of quartz-free feldspar, burned at cone 9, taken in ordinary light. Magnification, 100 diam.

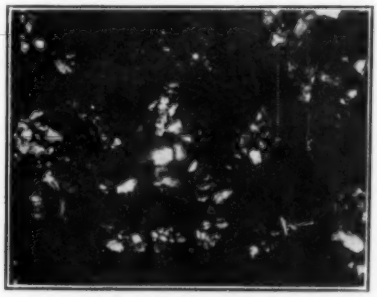


FIG. 2.—Same as Fig. 1, but taken in plane polarized light with crossed nicols. Note the dark feldspar glass and transparent remnants of crystalline feldspar.

FIG. 3.—Showing grains of quartz-free feldspar, burned at cone 12, taken in ordinary light. Magnification, 100 diam.

FIG. 4.—Same as Fig. 3, but taken with crossed nicols. The few transparent specks represent a trace of quartz. A comparison with Fig. 2 shows the effect of greater heat in fusing the feldspar.

FIG. 5.—Showing grains of feldspar containing 10% quartz, burned at cone 12, taken in ordinary light. Magnification, 100 diam.

FIG. 6.—Same as Fig. 5, taken with crossed nicols. Note the amount of quartz (transparent grains); their angular outlines indicate that no solution took place.

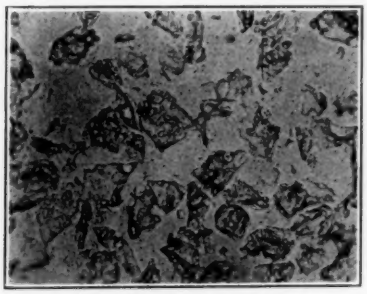


FIG. 7.—Showing grains of feldspar containing 20% of quartz, burned at cone 12, taken in ordinary light. Magnification, 100 diam.

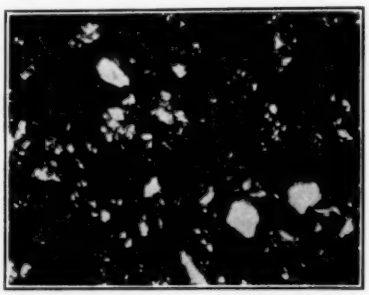


FIG. 8.—Same as Fig. 7 taken with crossed nicols. Note the increased content of quartz over that of Fig. 6.

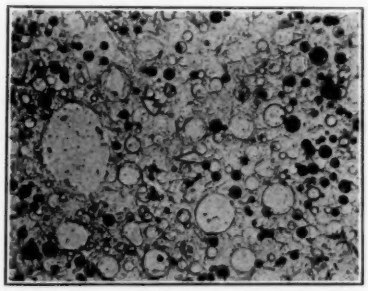


FIG. 9.—Showing thin section of New Hampshire feldspar, burned at specified cone with a 15-minute soak, taken in ordinary light. The circles of various light intensities are blebs. Magnification, 100 diam.

FIG. 10.—Same as Fig. 9, but taken with crossed nicols. Amount of quartz estimated at 10%. Note the lack of evidence of quartz solution.

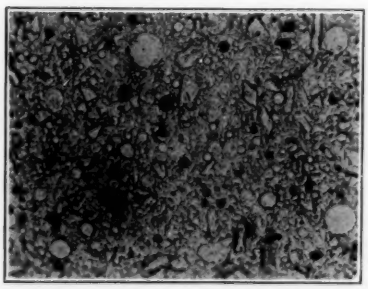


FIG. 11.—Showing thin section of Maine feldspar, burned at specified cone with a 15-minute soak, taken in ordinary light. Magnification, 100 diam.

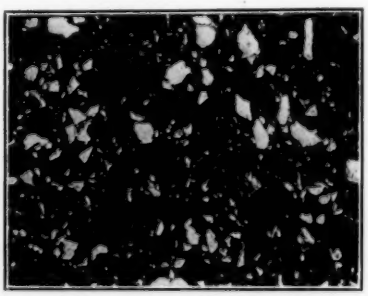


FIG. 12.—Same as Fig. 11 taken with crossed nicols. Quartz content was estimated at 30%. There is no evidence of quartz solution.

A slide is prepared by immersing a small amount of the grain in one of the above mentioned liquids and viewed first in ordinary light by removing the upper nicol prism then in polarized light by inserting it. In ordinary light the total amount of material in the field of vision is seen and in polarized light can be noted the amount of transparent material (quartz). Rotate the stage at least through 45° so that substantially all the quartz grains can be seen in some position or other. If a quartz grain is orientated exactly perpendicular to its "C" crystallographic axis it will remain black on rotation but the very small amount of grains thus orientated has in our experience no effect on the result since any error is well within the accuracy of this method. Quartz grains not so orientated will vary in color from dark gray through white to yellow.

If it is not necessary to determine the amount of quartz but merely to be assured of the uniformity of feldspars it remains only to prepare a permanent slide of a standard sample which shall be compared with subsequent products. Permanent slides are prepared by mounting the grains in a medium which becomes solid on standing, such as Canada balsam.

If it is desirable to know the amount of quartz present a sample of feldspar substantially free from quartz should be procured and to this known amounts of quartz added. Fusions of these mixtures will serve as reference points and permanent slides prepared from them can be compared as indicated with feldspars whose quartz contents are desired.

The ease and rapidity with which these comparisons can be made naturally depend upon the skill and technique acquired by repeated examinations. It is necessary to emphasize, however, that neither knowledge of polarized light nor of petrographic methods is required.

The method requires no elaborate equipment, the most expensive item being the simplest form of a polarizing microscope. Where only an ordinary microscope is available the two nicol prisms can be bought separately and fitted on without much trouble. In addition the following items are necessary: clove oil, Canada balsam, 2 sieves, microscope slides and cover glasses.

Referring to the photographs, Figs. 1, 2, 3, 4, 5, 6, 7, 8 represent the series in which known amounts of quartz were added to a feldspar originally substantially free from quartz. Figs. 9, 10, 11, 12 represent two types of commercial feldspars with differing quartz contents burned at the specified cone but with a difference in time of soak and indicate what variation in heat treatment is possible without producing any discrepancy in the results because of a loss of quartz due to solution in the feldspar glass.

NORTON COMPANY
RESEARCH LABORATORIES

Discussion

A. A. KLEIN:—This method for testing quartz has been used by Norton Company since June, 1922, and has proved very satisfactory. We are blending New Hampshire and Maine feldspar to insure a quartz content of 20%. Weekly samples are taken from the bins and the amount of each feldspar to be used depends upon the results obtained by the application of this method.

J. W. MANOR:—How are the figures arrived at after those slides are examined for percentages of quartz?

A. A. KLEIN:—We take the slides with known quartz content and compare them with the slides of feldspar whose quartz content is desired by the method described. A difference of 5% between them shows up very readily.

H. C. ARNOLD:—Are there any other possible minerals that would occur with feldspar which would not lose their crystalline nature at the point of fusion which he recommends?

A. A. KLEIN:—We have not found any yet. If there were any, they would be present in minor amounts and would not seriously affect the quartz values. Commercial feldspars are composed primarily of minerals of the feldspar group plus quartz and mica. The amounts of other minerals are relatively small.

A. S. WATTS:—Do you think that the artificial mixing of a pure feldspar free from quartz with the silica of commerce would produce a slide which we could use directly comparable to the natural quartz constituent of a pegmatite?

A. A. KLEIN:—Yes.

H. C. ARNOLD:—Do you find in a practical way that the indices of refraction method does not apply satisfactorily to the making of the basis of this investigation?

A. A. KLEIN:—This is not a practical method because most of the feldspars contain plagioclase whose refractive indices may be close to those of quartz itself, and the distinction by this optical constant is, therefore, doubtful. Moreover, even if no plagioclase were present it would be necessary to examine and count a great number of grains to insure reliable results. This would be a tedious task. The distinction between quartz and feldspar of similar indices of refraction by determining the interference is not feasible quantitatively because interference figures of quartz grains orientated parallel or nearly parallel to the "C" crystallographic axis are pseudo-biaxial and therefore not reliable.

H. C. ARNOLD:—I have examined quite a few. We never had such trouble. I wondered how it would be over a long period of time.

A. A. KLEIN:—From our experience the straight petrographic method

is at best a long, tedious one and can be applied with safety only under special conditions.

H. C. ARNOLD:—I am glad that Mr. Klein has presented this paper. I trust that it will be the forerunner of many more of a similar nature. The petrographic microscope is not finding the usage in the ceramic industry that its possibilities warrant. Its position in the study of rocks where the whole classification is based upon microscopic findings shows its possibilities. What can be done with rocks in thin sections can be done with powdered minerals immersed in oil.

I do not understand why Mr. Klein has confined himself to the index of refraction only in distinguishing the various minerals present in a commercial feldspar, nor why he resorts to fusing thereby destroying the very properties of value to him in determining the various ingredients. I would say that he has merely scratched the surface and not shown nearly all the possibilities of the petrographic microscope.

A. A. KLEIN:—The object of the paper was merely the determination of the quartz content of feldspar.

In order to afford a rapid fool-proof method, it was necessary to fuse, since by destroying the very optical properties in the original feldspar the distinction between it and the quartz became so apparent that one little versed in petrography could apply the method.

Our paper simply covered this point and was not a treatise on the general application of the petrographic microscope to ceramic problems. Of these applications we have discussed quite a few in the *Transactions* and the *Journal* and we quite agree that only a beginning has been made.

A STUDY OF THE ORIGIN AND CAUSE OF STONES IN GLASS[1]

By Herbert Insley

ABSTRACT

Stones occurring in glass are caused either by devitrification of the glass, by undissolved batch constituents, or by inclusion in the liquid glass of material from the refractory walls or crown.

Tridymite, cristobalite, wollastonite, diopside, and a new sodium-calcium-silicate are the usual devitrification minerals. In glasses of special composition, such as optical glass, other crystalline compounds are likely to result from devitrification.

Devitrification is the result of inhomogeneity in the melt, wrong batch composition, or exposure of the glass to temperatures favorable to crystallization of some component of the glass.

Incomplete melting is a cause of batch stones. Stones of this type may be due to undissolved sand grains, coloring oxide, or some other constituent. Impurities in the batch often resist solution and remain as stones.

Pot and tank stones are due to inclusions of pieces of the refractory walls in the glass. There are several varieties of such stones. Stones from the white layer on the inside of pots are composed wholly of sillimanite and dissolve with difficulty. Stones derived from tank blocks often contain particles of dehydrated clay matter as well as sillimanite and dissolve more readily than the pure sillimanite stones.

Stones containing corundum (Al_2O_3) are of two types: (1) stones from tank blocks which contained originally nodules of diaspore, bauxite or gibbsite; (2) stones from fire bricks above the glass line in which corundum has formed due to absorption of soda from the furnace atmosphere. The two types may be distinguished by their structure and their associations with other inhomogeneous materials. Determinations of the structure and the optical properties of stones by means of the polarizing microscope often enable one to discover the origin and cause of the stones.

Introduction

"Stones" are segregations of undissolved or crystallized material in glass. They may be introduced into the melt either from the glass and its constituents or from the walls and crown of the tank or pot in which the glass was made. The cause of stones and the means of eliminating them have always been serious problems for the glass manufacturer.

Bowen[2] has suggested the polarizing microscope as the most useful instrument for determining the composition of stones and has given the optical properties of most of the crystalline materials that are found as stones in optical glass.

The following results of a microscopic examination of a large number of specimens of stones show that there are many different types in the ordinary commercial glasses and that a careful study with the polarizing microscope at the plant will reveal not only their composition and whether

[1] By permission of the Acting Director of the Bureau of Standards of the U. S. Department of Commerce. Presented before the Glass Division, Pittsburgh Meeting, February, 1922.

[2] N. L. Bowen, "The Identification of Stones in Glass," *Jour. Amer. Ceram. Soc.*, **1**, 594–605 (1918).

they came from the glass itself or the refractory walls, but such a study in the case of pot and tank stones will also reveal the approximate position of the blocks that are the source of the stones and will often suggest remedies.

Devitrification Stones

Devitrification stones are caused by the crystallization of some constituent of the glass itself. They often take the form of spherulitic, radiating aggregates of a single crystalline substance.

Since silica is usually the most abundant constituent of a glass, devitrification crystals of the high temperature modifications, tridymite and cristobalite, are not at all unusual. A particularly striking example of this type of devitrification was observed in a piece of bottle glass which had lain in a flow spout between the refining end of the tank and the semi-automatic machine. Flame had been allowed to play on the surface of the glass for several days, the maximum temperature of the surface being from 1100°C to 1200°C. After this heat treatment, the glass contained white, opaque spheres, several of which were 1 inch in diameter. Under the microscope the white spheres were found to be full of what appeared to be crystalline needles embedded in glass. (Fig. 1.) The needles had the negative elongation, low double refraction and low indices of refraction (near 1.47) of hexagonal tridymite plates turned on edge. With a very high power the hexagonal outlines of some of the plates could be seen. The longest dimension of the plates was rarely more than 0.05 mm. and they were less than 0.003 mm. thick.

FIG. 1.—Hexagonal plates of tridymite (turned on edge) embedded in glass. Caused by devitrification of bottle glass. Magnification, 50 diam.

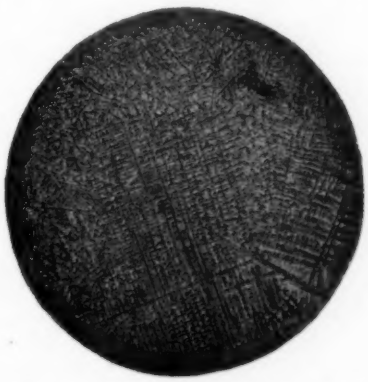


FIG. 2.—Parallel growths of skeleton crystals of cristobalite in devitrified glass from the "dead" regions immediately adjoining the bridge in a tank of bottle glass. Magnification, 50 diam.

Devitrification stones which contain cristobalite or mixtures of cristobalite and tridymite have been observed in several instances. A piece of devitrified glass from the "dead" regions immediately adjoining the

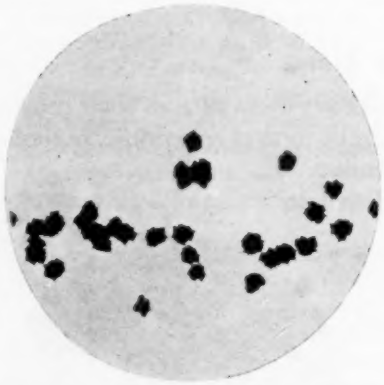


FIG. 3.—Spherulites of cristobalite grouped along striae in lead flint glass. Magnification, 9 diam.

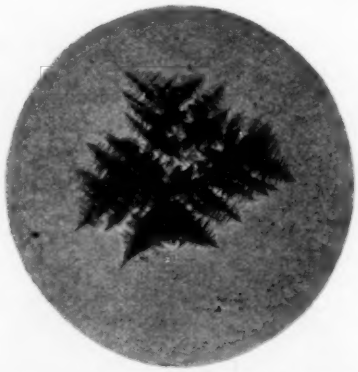


FIG. 4.—One of spherulites in Fig. 3, magnified 47 diameters.

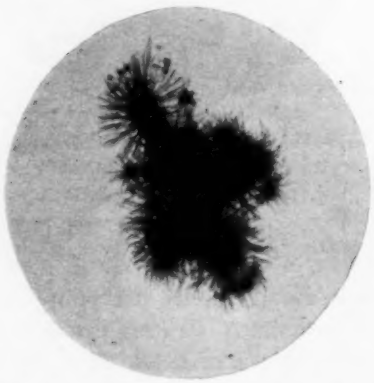


FIG. 5.—Wollastonite spherulite in sheet glass. Magnification, 7 diam.

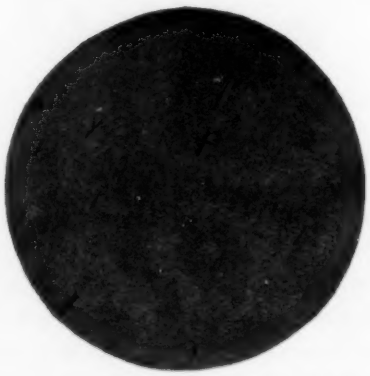


FIG. 6.—Devitrification crystals of a sodium-calcium-silicate in plate glass. Long axes of the crystals are parallel to plane surfaces of the plate glass. Magnification, 8 diam.

bridge in a tank of bottle glass consisted of skeleton crystals of cristobalite which had grown in long parallel arrangements. (Fig. 2.) Individuals had very low double refraction, low indices of refraction (near 1.48) and sometimes showed twinning. The forms mentioned by Fenner[1] were characteristic. The extensive development of the cristobalite and the

[1] C. N. Fenner, "The Stability Relations of the Silica Minerals," *Amer. Jour. Science*, **36** [4], 331–84 (1913).

presence of only a few tridymite crystals would seem to indicate that the temperature was within the range where cristobalite is stable. Apparently devitrification was due to a concentration of silica in that part of the tank.

In a lead flint glass rather high in lead, lines of spherulites of cristobalite followed striae in the glass. (Figs. 3 and 4.) These showed the pine tree forms which are sometimes characteristic of cristobalite spherulites. Devitrification occurred along the striae because they were higher in silica, the crystallizing constituent, than the rest of the glass.

Silicate glasses which are rather high in lime sometimes contain devitrification crystals of wollastonite ($CaSiO_3$). A particularly large wollastonite spherulite 12 mm. in length was found in a piece of sheet glass. This showed the characteristic radiating plumose structure of wollastonite crystals in glass. (Fig. 5.) One block of window glass containing about 13% lime was full of fine spherulites of wollastonite which were arranged in more or less parallel layers. The layers were somewhat curved and devitrification was apparently due to the fact that these layers contained somewhat more lime than the rest of the glass.

Crystals of a new sodium calcium silicate, the exact composition of which is not known, were first observed in glass by Prof. A. B. Peck. Since that time they have been observed by the writer in at least two specimens of glass. In one they occurred as the crystalline portion of a partly devitrified glass which was taken from the "dead" corner of a glass tank. A piece of plate glass contained the same compound in almost perfect prismatic crystals scattered through the glass and oriented more or less parallel to the plane surfaces of the glass. (Fig. 6.) In arrangement and size these crystals are very similar to wollastonite crystals found by Bowen[1] in a piece of plate glass rather high in lime. The growth of these crystals was ascribed by him to the length of time the glass had been held in the pot immediately before casting. Difference in original composition of the batches probably caused the difference in the kind of crystals formed, but the cause of formation of crystals in both cases was probably the same.

Diopside ($CaMg(SiO_3)_2$) sometimes crystallizes as a devitrification product in glass where dolomitic limestone is used in the batch. In one piece of sheet glass examined, long prismatic crystals of diposide grew in a cord in the glass. At the center of the growth the crystals formed a small, radiating tuft. Evidently the cord was somewhat higher in lime and magnesia than the rest of the glass.

Devitrification crystals may be due to several causes, but the manner in which the crystals occur often suggests the true one. Crystals along cords or in layers are probably due in part to inhomogeneity in the melt. Those which occur in large masses or spread evenly through the glass are

[1] N. L. Bowen, "Devitrification of Glass," *Jour. Amer. Ceram. Soc.*, **2**, 271 (1919).

due either to an excess of one constituent in the batch or to the heat treatment during cooling. The crystalline compound formed as the result of devitrification will, of course, depend on the original batch composition and the temperature at which devitrification takes place.[1] There are undoubtedly many other devitrification crystals which have not yet been examined microscopically. Unusual devitrification crystals are likely to occur in glasses of special composition.

Batch Stones

Batch stones are the result of batch constituents or impurities remaining undissolved in the melt. The constituent that is most frequently

FIG. 7.—Batch stone in bottle glass. Partly dissolved quartz grains surrounded by inversion rims of tridymite. Increase of the silica content of the glass in the vicinity of the quartz grains has caused devitrification crystals of tridymite to form. Magnification, 18 diam.

FIG. 8.—Scum from top of melting surface in tank. A mixture of tridymite and cristobalite. Crossed nicols. Magnification, 18 diam.

left undissolved in the melting process is silica. Bowen[2] has already given the distinguishing characteristics of this type of stone. A typical silica batch stone is shown in Fig. 7. Plates of tridymite (turned on edge in figure) can be seen radiating from centers which are remnants of quartz grains. The quartz centers are surrounded by rims of fine-grained tridymite which show every indication of having gone through an intermediate cristobalite stage.

Salt-cake (sodium sulphate), when it is introduced into the batch in moist lumps, resists decomposition. It then usually rises to the surface as "gall" or scum but sometimes it remains suspended as lumps and white

[1] A more complete discussion of devitrification is given by Bowen in the *Jour. Amer. Ceram. Soc.*, **2**, 261–81 (1919).

[2] N. L. Bowen, "The Identification of Stones in Glass," *loc. cit.*

blotches in the finished glass. These white blotches can be distinguished from devitrification spherulites by the irregular shape of the former. The microscope shows this kind of stone to be made up of agglomerates of very fine particles which are apparently amorphous. Small crystals are sometimes found in them.

Foreign materials in the ingredients are a rather frequent and troublesome source of batch stones. At least two cases were studied where the stones were the result of lumps of clay and soil in the limestone. At times it is difficult to distinguish such stones from clay stones from tank blocks, but generally clay from the limestone does not show such extensive alteration to sillimanite and there are usually characteristics of composition and fineness of grain which are sufficient to distinguish the two types.

When unusual batch ingredients, such as coloring oxides, are used they sometimes contain lumps of impurities which are relatively insoluble in the melt and thus are a source of stones. Difference in grain size and structure and absence of crystalline matter will generally distinguish this kind of stone from stones from other sources. The coloring oxides themselves may be a cause of stones. Davidson[1] has noted that dark spots in chromium green glass are due to undissolved chromium oxide.

Stones caused by particles of "scum" which have become detached from the main mass of the scum and incorporated in the glass can be classed as either batch stones or devitrification stones. Several specimens of the scum which forms on the surface of liquid glass near the melting end of the tank have been examined microscopically and have been found to be composed of a mixture of tridymite, cristobalite and glass. (Fig. 8.) The top of the scum is usually made up of large well-formed hexagonal plates and wedge-shaped twins of tridymite. Near the contact of the scum with the clear glass there is considerable cristobalite mixed in with the tridymite. Thin sections of the scum show circular outlines which are filled with closely packed, wedge-shaped tridymite twins, indicating that a part of the scum was formed from undissolved grains of quartz which floated to the surface of the melt and later inverted to tridymite. A large part of the scum, however, is undoubtedly formed by the devitrification of the highly siliceous liquid at the surface of the melt.

Crown Drops

Since most American furnace crowns are made of silica brick, any liquid that drips from the crown into the glass is likely to be highly siliceous. Crystals of tridymite are often carried with this liquid into the glass. Bowen has described the characteristics of tridymite crystals introduced into the glass with crown drops.

[1] J. H. Davidson in general discussion at meeting of the Society of Glass Technology, reported in *Jour. Soc. Glass Tech.*, **6**, 3–17 (1922).

Where fire-clay brick is used in the crown as is sometimes done in England the resulting crown drops will, of course, have an entirely different composition. Such drops will be discussed under tank stones.

Pot or Tank Stones

The most prevalent stones are those produced from the corrosion of pot or tank walls by the molten glass. The appearance of such stones will, of course, depend on the composition of the blocks from which they come, the heat treatment they have undergone, and whether they come from below or above the surface of the glass.

FIG. 9.—Normal clay stone showing mass of fine, amorphous clay particles with partly dissolved quartz grains (at left side of amorphous material) and a few sillimanite crystals (at right side of amorphous material). Magnification, 100 diam.

Stones from below the glass line and from normal fire clays will be first considered. The clay in the inner walls of pots is usuallyc onverted to sillimanite and glass, stones from pot walls therefore are composed of this mixture. Stones from tank blocks do not usually show such complete conversion. Corrosion in tank blocks may begin in a crevice or crack into which the glass readily penetrates, finally separating a large piece of clay from the main portion of the tank block. Where such a piece of clay had long exposure to high temperatures but was not in contact with the glass for any length of time before breaking away from the block, large and numerous crystals of sillimanite might form and remain in the glass after cooling. Microscopic examinations indicate that more often there is not any considerable transformation to sillimanite before the piece of clay is floated away from the tank block. After it is embedded in the glass transformation of clay matter to sillimanite may take place at the periphery. If quartz grains are present, they are gradually dissolve in the glass. The fine, amorphous particles of dehydrated clay matter persist at the center of the piece. (Fig. 9.) A number of specimens of tank stones examined contained such a surprisingly small amount of sillimanite that it seems likely that solution of a portion of the amorphous clay matter in the glass took place before transformation to sillimanite. The relative amount of sillimanite in a tank stone may give some information as to the portion of the tank from which the stone came. Stones which contain large quantities of well-developed sillimanite with little

trace of untransformed amorphous material evidently came from tank blocks which had been exposed to high temperatures for long periods of time.

The discovery of crystals of corundum (Al_2O_3) as stones in glass was surprising and unlooked for as their presence had not heretofore been suspected. Microscopic examination showed that corundum stones were not at all rare and, due to their insolubility in the glass, were probably very persistent.

The position of corundum stones in sheet glass is usually marked by a large lump, the lump being due to the higher viscosity of the glass containing alumina in the immediate vicinity of the corundum crystal.

The presence of corundum in certain tank blocks has been noted by Wilson in a paper[1] which gave the results of a petrographic and chemical analysis of a fire-clay brick which had been in use in the crown of an English tank furnace. The end of the brick which was farthest from the interior of the furnace was apparently unaltered. The zone a little nearer to the interior had a white, vitrified appearance and consisted of minute crystals of sillimanite in a glassy base. The inside end of the brick consisted of a brown glass full of thin, hexagonal plates of corundum. A chemical analysis of the unaltered brick showed about 64% silica, 30% alumina, and about 0.5% alkalies (soda and potash). The fused end of the brick contained about 42% silica, 40% alumina and 10% alkalies. Several analyses of such bricks showed the same remarkable increase in alkalies in the fused ends of the brick as compared to the unaltered ends. The added alkali was undoubtedly largely soda which was absorbed by the brick from the furnace atmosphere. Analyses of the glassy portions of the brick after the content of corundum and sillimanite had been subtracted showed that the molecular ratios of soda to alumina to silica were about 1 to 1 to 5, or, as Wilson supposed, "the composition is made up of about equal proportions of the albite ($Na_2Al_2Si_6O_{16}$) and the nephelite (or the high-temperature form, carnegeite) ($Na_2Al_2Si_2O_8$) molecules." At any rate, the increased soda combined with the alumina and silica to form a compound which was liquid at furnace temperatures. If there was excess of both alumina and silica above the ratio necessary for this compound, they united to form sillimanite and if there was still excess alumina after the silica had been satisfied corundum crystallized or if there was still excess silica after the alumina had been satisfied, tridymite or cristobalite crystallized. Thus, depending on the original composition of the brick and the amount of alkalies which had been absorbed from the furnace atmosphere, the fused end of the brick would consist of: (1) silica (tridymite or cristobalite) and liquid, (2) sillimanite, silica and liquid, (3)

[1] G. V. Wilson, "Notes on the Formation of Certain Rock-Forming Minerals in and about Glass Furnaces," *Jour. Soc. Glass Tech.*, **2**, 197–213 (1918).

corundum, sillimanite and liquid, or (4), corundum and liquid. Since the alumina in fire bricks is rarely less than the amount required to form the proper proportions with soda and silica for the liquid compound, it is scarcely possible that tridymite or cristobalite will be found in the fused ends of such bricks. As this liquid sodium-aluminum-silicate forms, it will tend to run off the end of the brick and drip down into the glass. Frozen drips of this kind have been collected and analyzed by Wilson.

Wilson does not consider the possibility of corundum being carried into the glass with the drips, but undoubtedly this does happen. The fire brick in the back wall of a pot furnace at the Bureau of Standards used for melting glass were found to be covered with a layer of corundum and glass after the furnace had been in use for some time. Frozen drips depending from the lower edges of some of the bricks consisted of glass and corundum. The percentage of corundum in the drips was not as great as in the end of the brick and probably drips would have ceased to fall after a protecting network of corundum crystals had formed in the end of the brick.

A piece of a clay block from the top of a bridge in a continuous tank where it was exposed to the furnace atmosphere has been examined by the writer. It has many of the characteristics of the brick examined by Wilson. The original clay block from which the specimen came consisted largely of Missouri plastic clay and Missouri or Pennsylvania flint clay. The specimen itself is less than an inch thick. The part which represents the interior of the brick is white and somewhat vitreous and is full of sillimanite needles in a glassy matrix. In portions successively nearer the outside of the brick (the end in the furnace chamber) the sillimanite crystals become larger but less in quantity in relation to the glass until the sillimanite disappears completely and corundum begins to appear. The outer $^3/_8$ inch is brown and glassy in appearance. The inner part of this brown glass is composed of about 25% corundum and 75% glass. In the extreme outer edge there is slightly more corundum than glass.

The hexagonal plates of corundum in the stones are very similar in appearance to those in the end of the brick just described. (Fig. 10.) In both the crystals are fairly large (0.2–1 mm.) and the crystal faces are sharp and well defined. Inclusions of glass which were originally liquid are characteristic of the corundum crystals in the brick and of those in the stones. These inclusions are arranged approximately parallel to the sides of the hexagonal plates. The evidence as to the source of this kind of stone seems conclusive.

In order to eliminate this type of corundum stone, the possibility of substituting brick containing a very high percentage of alumina and a low percentage of silica should be considered. The amount of sodium aluminum silicate (liquid at furnace temperatures) formed by the absorp-

tion of soda would be so small that it would not drip off into the glass and would serve merely as a medium in which the corundum could crystallize. The layer of crystalline corundum formed on the surface of the brick should act as a very efficient protective covering for the rest of the brick.

A few samples of stones contained corundum with such different associations and characteristics from those which originated in the brick above the melting surface that a different origin had to be sought for them. In this type the corundum crystals were always small, seldom more than 0.08 mm. in diameter. Generally the crystals had rounded faces, although many showed unmistakable hexagonal outlines. In almost all cases the

FIG. 10.—Corundum crystals which have dripped off end of fire-clay brick above glass line and fallen into glass. Cloudy areas at upper right and upper left are crystals apparently formed by reaction of the corundum with the glass and are probably sillimanite. The dark circular mass in the center of the photograph is a bubble which has been filled with abrasive material. Magnification, 23 diam.

FIG. 11.—Small corundum crystals (in center of figure) in stone in glass, probably caused by conversion of nodules of diaspore to corundum in flint clay. Note amorphous mass just below corundum and crystalline material just above corundum (latter probably formed by reaction between corundum and glass). Magnification, 100 diam.

crystals were found surrounding very fine, apparently amorphous grains with index of refraction as high or almost as high as that of the corundum. (Fig. 11.) In some cases the small corundum crystals and high index amorphous material are associated with normal clay stones with amorphous clay matter in the center and partly dissolved quartz grains and crystals of sillimanite at the periphery.

A microscopic examination of some high alumina refractory blocks which had been used in a Dressler tunnel kiln suggested a possible source for the second type of corundum stone. In these blocks the bond clay

had been transformed to a network of large sillimanite crystals, while the coarser particles contained grains of corundum surrounded by a small amount of sillimanite. The corundum grains, like those noted above, had rounded faces and, in fact, had almost lost all distinguishing crystal form. The original refractory clay had evidently been a so-called "flint" clay which had contained nodules of diaspore (Al_2O_3 H_2O) or gibbsite (Al_2O_3 $3H_2O$). On burning, the bond clay had altered to a mixture of sillimanite needles and siliceous glass and the nodules to corundum. It is well known that certain flint clays, such as those of Missouri, contain nodules of gibbsite or diaspore.

The evidence obtained indicates that the second type of corundum stone originated in pot walls or tank blocks which contained flint clay carrying hydrated aluminum oxide nodules. The high temperatures caused the nodules to change to corundum before the pieces of clay were floated away in the molten glass.

In general there are several characteristics which may serve to differentiate corundum stones originating in tank blocks above the glass line from corundum stones originating in tank blocks below the glass line. In stones originating in blocks above the glass line the crystals are large (0.2 mm.–1 mm.), well formed, hexagonal plates, often containing inclusions of glass. They are never associated with fine particles of amorphous matter or with normal clay stones. When, however, the stones originate in blocks below the glass line, the crystals are small (rarely more than 0.08 mm.), do not often show well-defined faces, and seldom carry inclusions of glass. Often segregations of untransformed particles of amorphous matter remain with the crystals and the crystals are sometimes associated with normal clay stones.

The elimination of corundum stones is very important for corundum stones once formed are relatively insoluble in molten glass of the ordinary soda-lime type.

NOTE: Many of the data given in this paper were obtained on specimens furnished by Mr. D. W. Ross, of the Findlay Clay Pot Co. Thanks are due to him and to Mr. W. F. Brown, chief chemist of the Libbey-Owens Sheet Glass Co., who furnished interesting samples of glass containing stones. The advice of Mr. A. E. Williams, chief of the Glass Section of the Bureau of Standards, has enabled the writer to understand the relations between his laboratory results and commercial melting practice.

CLAY SEWER PIPE MANUFACTURE

II.—The Effect of Variable Alumina, Silica and Iron Oxide in Clays on Some Properties of Salt Glazes[1]

By H. G. Schurecht[2]

ABSTRACT

Introduction.—A study was made of the relations between the alumina, silica and iron oxide contents in clays and their ability to take a salt glaze.

Color.—Under the conditions of these tests it was found that low silica clays containing 0 to 1.00% iron oxide and high silica clays containing 0–2.19% iron oxide in terms of calcined weight produced white to tan glazes; low silica clays containing 1.00 to 3.5% and high silica clays containing 2.19 to 3.5% produced light brown glazes; those having 3.5 to 4.75% produced brown glazes; clays containing 4.75 to 8.2% produced mahogany glazes; and those having more than 8.2% possessed dark brown to black glazes.

Brightness.—With clays similar to those tested in this work and which are fired and glazed to the same temperature, the brightness of a salt glaze which will be produced on it, may be predicted by calculating G in the following expression:

$$-1.00x_1 + 0.376x_2 - 2.923x_3 = 100G.$$

x_1, x_2 and x_3 represent the percentages of alumina, silica and iron oxide in the clay in terms of calcined weight. If G is greater than zero the salt glaze will be bright; when between —0.1337 and 0, it will be semi matt; and when less than —0.1337 it will be matt.

Thickness of Glaze.—The thickness of the salt glaze may be increased 600 per cent by increasing the silica content in a pure clay.

Introduction

Thick smooth glazes on sewer pipe are desirable since they make the pipe more impervious to water and are especially desirable if the body is somewhat porous. The glaze also protects the body of the pipe from the action of chemicals in the sewage as well as the abrasion of sand which is often carried through with the sewage.

The inability of clays to take a salt glaze is largely the cause of unglazed pipe and dull thin glazes. The use of bodies having a composition approaching that best suited for taking a salt glaze would, therefore, result in the production of pipe of better quality, and reduce losses in their manufacture.

That some clays take a salt glaze better than others is known, but what the composition of a clay should be to take a salt glaze is not known. Langenbeck[3] suggested that a clay must have 8 molecules of silica to one

[1] Published through the courtesy of The Eastern Clay Products Association and The Clay Products Association under whose auspices this work has been conducted as a part of their research program on the manufacture of clay sewer pipe. A third paper on this subject will appear in the July *Journal*.

[2] Industrial Fellow, The Mellon Institute of Industrial Research, University of Pittsburgh, Pa.

[3] Karl Langenbeck, "Chemistry of Pottery," 90.

of alumina before it will take a good salt glaze; Barringer[1] reported that 4.6 molecules of silica is the lower limit; while Mackler[2] stated that clays having 3.3 molecules of silica to one of alumina will take a salt glaze.

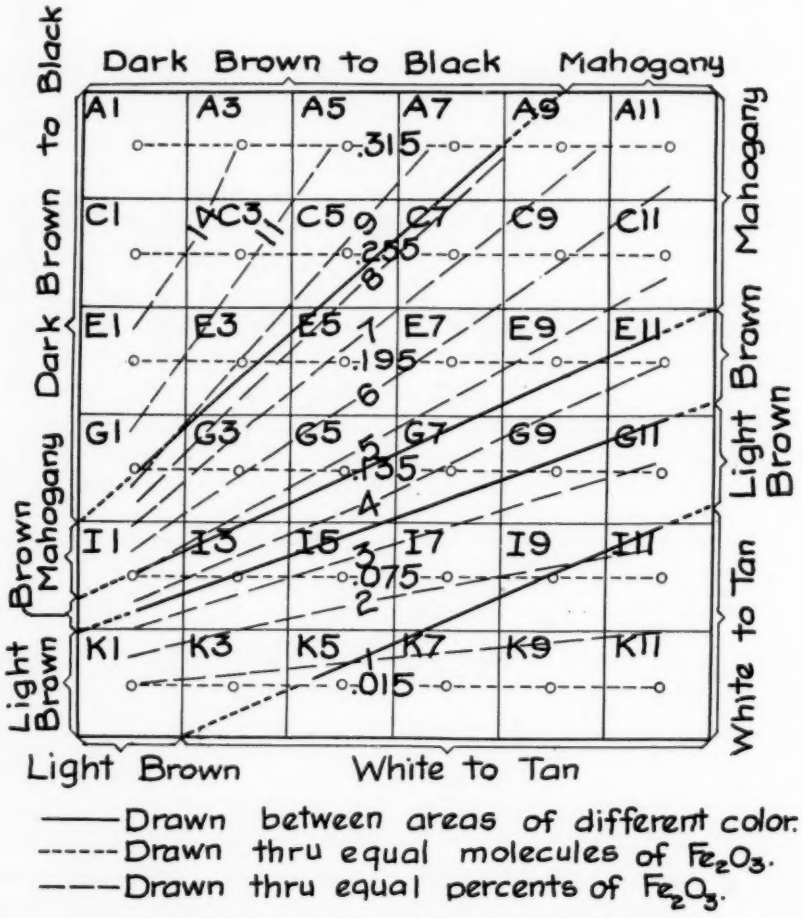


FIG. 1.—The influence of iron oxide on the color of salt glazes.

Experimental Methods of Present Study

Thirty-six synthetic clays with varying chemical compositions were prepared. The silica, alumina and iron oxide contents were varied between the following limits:

Alumina (Al_2O_3) = 12.30–37.18%.
Silica (SiO_2) = 38.40–80.95%.
Iron oxide (Fe_2O_3) = 0.33–16.40%.

[1] L. E. Barringer, *Trans. Amer. Ceram. Soc.*, **4**, 222 (1902).
[2] Mackler, *Tonind. Ztg.*, **251**, 440 (1905).

The mixtures were prepared by adding varying amounts of potter's flint and iron oxide to a 1:1 Florida kaolin-Tennessee ball clay mixture. The clays had a composition corresponding closely to that of a pure clay and at the same time were fine grained having a structure very similar to the secondary clays used for sewer pipe manufacture. Since impure clays are usually mixtures of a pure clay and minerals, the addition of flint and iron oxide to these produces a mixture which has a mineralogical composition similar to the impure clays used for the manufacture of sewer pipe.

The mixtures were prepared according to the diagram shown in Fig. 1. The four corners correspond to the following compositions:

$$\left.\begin{matrix} A1 = 1.00\ Al_2O_3 \\ 0.30\ Fe_2O_3 \end{matrix}\right\} 2.00\ SiO_2$$

$$\left.\begin{matrix} A11 = 1.00\ Al_2O_3 \\ 0.30\ Fe_2O_3 \end{matrix}\right\} 10.00\ SiO_2$$

$$K1 = 1.00\ Al_2O_3\ \ 2.00\ SiO_2$$

$$K11 = 1.00\ Al_2O_3\ 10.00\ SiO_2$$

The raw mixtures were molded into $^1/_2'' \times {}^1/_2'' \times 1^3/_4''$ briquettes which were scored on two sides to facilitate in breaking them for a microscopic examination of the different glazes produced on them. These trial pieces were set in clay pats together with standard cones and were fired and salt glazed in a commercial sewer pipe kiln at cones 2–3. To check the deformation cone on the test pat, which was exposed to salt fumes during the glazing, similar cones were also placed in small saggers near the test pat. Thus the deformation cone in the absence of salt fumes was obtained as well as that softening in the presence of salt fumes. In this test cone 3 deformed outside of the sagger and cone 2 inside.

After the specimens had been fired and glazed, they were broken and the thicknesses of the different glazes were measured under a microscope.

Experimental Results

The Effect of Variable Silica, Alumina and Iron Oxide in Clays on the Color of Salt Glazes.—The effects of different ingredients in clay upon the color of salt glazes are shown in Fig. 1. The squares lettered A–1.....K–11 represent the different mixtures. The dotted lines are drawn through the points which represent mixtures having the same molecular quantities of iron oxide while the dash lines pass through points which have the same percentage iron oxide in terms of the calcined weight of the mixture. The areas having different colors are separated by heavy solid lines and the colors of these are indicated on the margins.

The lines separating the different areas coincide fairly closely with those representing equal *percentages* of iron oxide. For example those clays which have more than 8.2% iron oxide produce a dark brown to a black glaze; those containing between 4.75 and 8.2% iron oxide take mahogany

glazes; and those having between 3.5 and 4.75% produce brown glazes. The dividing line between light brown and white to tan glazes does not coincide with the line representing equal percentages iron oxide but varies from 1.00 to 2.19% iron oxide for clays containing 54.90 to 83.75% silica, respectively.

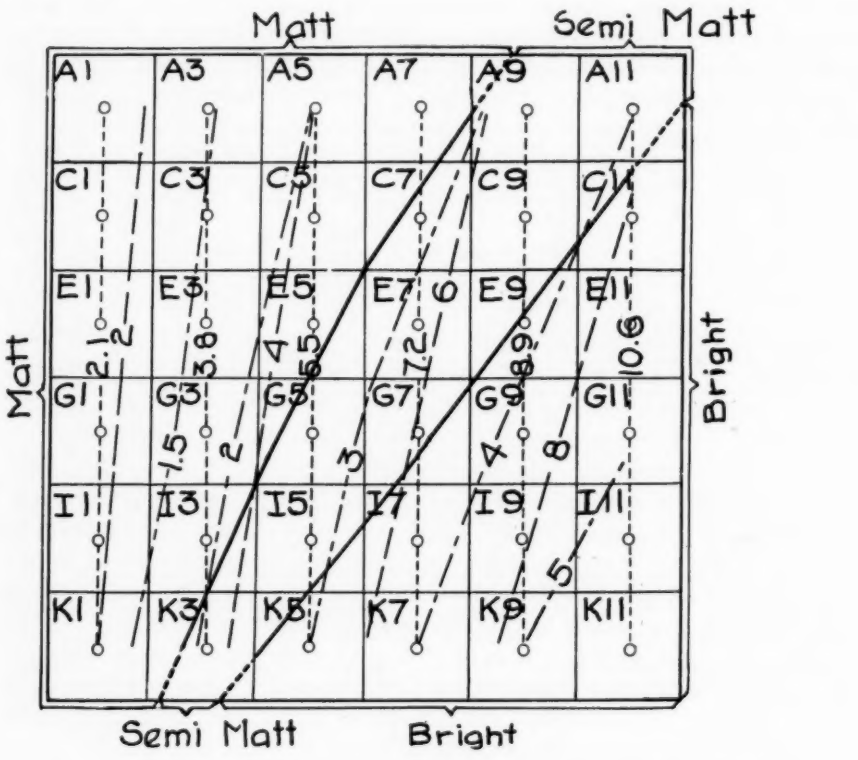


FIG. 2.—The influence of the chemical composition of clays on the glossiness of salt glazes.

The dotted lines drawn through squares, representing clays having equal *molecular proportions* of iron oxide (unlike the case of equal percentages) in no cases coincide with the lines dividing the areas of different color but instead cross these showing that there is no close relation between the molecular quantities of iron oxide and the color of the glaze.

The Effect of Variable Silica, Alumina and Iron Oxide in Clays on the Brightness of Salt Glazes.—The relation between the variable silica, alumina and iron oxide contents in clays on the brightness of salt glazes is shown in Fig. 2. The dotted lines are drawn through points representing clays having equal ratios of molecules of silica to molecules of alumina. The dash lines pass through points having equal ratios of molecules of silica to molecules of alumina plus iron oxide and the dot and dash lines are drawn through points having equal ratios of per cent silica to the per cent alumina plus iron oxide.

The heavy solid lines are drawn between areas having different degrees of brightness and these areas are designated in the margins as bright, semi matt and matt glazes. By matt glazes are meant dull rough glazes having the appearance of vitrified clay without a glaze. Bright glazes are those which have a bright and glossy appearance similar to glass. By semi matt glazes are meant those which are too dull to be classed as bright but still are not as dull as the true matt glazes. Those semi matt glazes lying near the bright glaze area have only a thin matt skin on the surface of the glaze which can only be seen by looking at the glaze at an angle, while the semi matt glazes near the matt glaze area have a thick matt skin.

By examining the diagram it is seen that neither the dotted, dash or dot and dash lines coincide with the lines separating the gloss, semi matt and matt areas, showing that there is no close relation between the glossiness of salt glazes and ratios of molecules of silica to molecules of alumina, molecules of silica to molecules of alumina plus iron oxide or percentage of silica to percentage of alumina plus iron oxide.

With clays containing no iron oxide, the division between semi matt and bright glazes falls upon a clay having a ratio of percentage silica to percentage alumina of 2.66 while with those containing 6% iron oxide, the division falls on a clay whose ratio of percentage silica to percentage alumina plus iron oxide is 4.28. It is evident that the iron oxide under the conditions of this experiment has a greater tendency to produce matt glazes than alumina. In order to show this difference mathematically the writer determined gloss values for the three oxides in the following formula which may be used within the limits of composition of this experiment to predict what type of glaze a similar clay will take from the chemical analysis.

$$x_1g_1 + x_2g_2 + x_3g_3 = 100G \qquad (1)$$

x_1, x_2 and x_3 represent, respectively, the percentages of alumina, silica and iron oxide in clays in terms of calcined weight; g_1, g_2 and g_3 represent the gloss values which were found to be —1.00, 0.376 and —2.923 for alumina, silica and iron oxide, respectively, and G represents the gloss factor of the glaze produced with this clay which increases in proportion

to the brightness of the glaze produced. Thus by substituting the percentages of the oxides in terms of calcined weight of clay in the above equation and multiplying each by their respective gloss values, a value G, may be calculated. When G is greater than 0 the clay will produce a bright glaze provided it is fired under conditions similar to those under which the test pieces were fired. When G is between —0.1337 and 0 the glazes will be semi matt and when below —0.1337 they will be matt.

The above gloss values were determined from this first experiment only. The values for silica and alumina will probably be about the same for all conditions but that for iron oxide will vary for different kiln atmospheres. Under reducing conditions it will be —2.923+. Just how much it will be changed will be determined in subsequent work and after having been estimated it will enable the burner to predict how much the glaze will be changed by varying the kiln atmosphere from oxidizing to reducing in firing.

Mathematical Derivations.—The percentages of silica and alumina in a clay having a ratio of percentage silica to percentage alumina of 2.66 are 72.70 and 27.30, respectively. This composition represents, therefore, the division between bright and semi matt glazes in the iron-free mixtures.

Giving to g_1 the value —1.00 and to G the value 0, we obtain a value for g_2 by means of equation 1 as follows:—

$$27.30\ (-1.00) + 72.70g_2 + 0g_3 = (100)\ (0)$$

$$g_2 = \frac{27.30}{72.70} = 0.376$$

The ratio of percentage silica to percentage alumina plus iron oxide for clays having a composition falling upon the dividing line between bright and semi matt glazes is 4.28 for clays containing 6 per cent iron oxide. The percentages alumina and silica for such a clay may be calculated as follows:

$$x_1 + x_2 + 6 = 100$$

$$\frac{x_2}{x_1 + 6} = 4.24$$

$$\therefore x_1 = 12.91 \text{ and } x_2 = 81.09.$$

Substituting these values in equation 1 with G equal to 0 we can calculate a value for g_3 as follows:

$$(12.91)\ (-1.00) + (81.09)\ (0.376) + 6(g_3) = (100)\ (0)$$

$$g_3 = -2.923.$$

Substituting these gloss values for alumina, silica and iron oxide, the ratios, (R_1), of per cent silica to per cent alumina plus iron oxide were determined for different values of x_3 as follows:—

For $x_3 = 1$ $\quad x_1(-1.00) + x_2(0.376) + 1(-2.923) = 0$

$-99 + x_2(0.376) - 2.934 = 0$

$x_2 = 74$

$R_1 = 2.84$

For $x_3 = 2$, $R_1 = 3.08$.

For $x_3 = 6$, $R_1 = 4.28$.

In this manner it was found that

$$R_1 = f(x_3) = (0.162 + 0.01x_3^{1.328})x_3 + 2.66 \qquad (2)$$

When a line is drawn through points (Fig. 2) having values of R_1 equal to the above expression it was found to divide the bright glazes from the semi matt glazes as accurately as it is possible to detect by a visual examination, and therefore, for practical purposes may be used to represent the ratios of per cent silica to per cent alumina plus iron oxide dividing the bright and semi matt glazes.

We find by examining the iron free clays that the division point between matt and semi matt glazes is represented by the mixture in which the ratio of per cent silica to per cent alumina plus iron oxide is 1.70. Using the same gloss values as were determined above for the oxides in this clay, we obtain —0.1337 as the gloss factor G, which divides the matt from semi matt salt glazes produced on the iron-free mixtures. This value for G was calculated as follows:

$$(37.02)(-1.00) + (62.98)(0.376) + 0(-2.923) = 100G.$$

$$G = -0.1337.$$

The ratios, (R_2), of per cent silica to per cent alumina plus iron oxide for clays containing 6% iron oxide and having a gloss factor, G, of —13.37, was found to be 2.51 as follows:

$$x_1(-1.00) + x_2(0.376) + 6(-2.923) = (100)(-0.1337)$$

$$-94 + 1.376\,x_2 - 17.538 = 13.37.$$

$$x_2 = 71.30$$

$$R_2 = 2.51$$

$$R_2 = f(x_3) = (0.105 + 0.001x_3^{1.898})x_3 + 1.70 \qquad (3)$$

Equation 3 was obtained in a manner similar to that used in obtaining 2. The values for R_2 when plotted on the gloss diagram (Fig. 2) were found to divide the semi matt and matt area as accurately as was possible by a visual examination of the glaze.

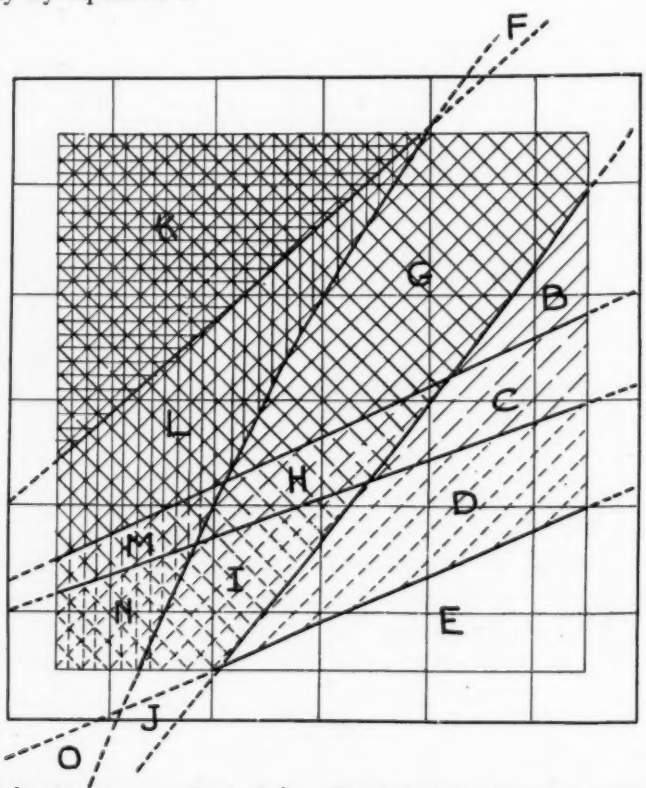
According to Sortwell[1] porcelain glazes having the best gloss have their molecular quantities of alumina equal to 0.3 plus $^1/_{12}$ silica. This value for some iron-free salt glazes which are similar to porcelain glazes in composition would correspond to a glaze having a ratio of per cent silica to per cent alumina of 5.30. The gloss value G for such glazes would be +0.1576

[1] H. H. Sortwell, "High Fire Porcelain Glazes," *Jour. Amer. Ceram. Soc.*, **4**, 729 (1921).

and the values for the ratios (R_3) per cent silica to per cent alumina plus iron oxide for clays having this gloss factor would approximately be as follows:

$$R_3 = (0.48 + 0.01x_3^{2.336})x_3 + 5.30 \quad (4)$$

The writer has not yet covered the high iron oxide clays having this value for G experimentally but it is probable that the glazes of highest gloss would be produced on clays having values for R_3 represented approximately by equation 4.



B–Mahogany Bright.
C–Brown Bright.
D–Light Brown Bright.
E–White to Tan Bright.
F–Dark Brown to Black Semi Matt.
G–Mahogany Semi Matt.
H–Brown Semi Matt.
I–Light Brown Semi Matt.
J–White to Tan Semi Matt.
K–Dark Brown to Black Matt.
L–Mahogany Matt.
M–Brown Matt.
N–Light Brown Matt.
O–White to Tan Matt.

FIG. 3.—The influence of variable silica, alumina and iron oxide in clays on the color and gloss of salt glazes.

In reviewing the literature[1] on the crazing of glazes it was found that for porcelain glazes this occurs when the gloss factor lies above 0.16–0.20. The values for G were calculated from the ratio of per cent silica to per cent alumina in the glazes similar to salt glazes in composition.

Since clays having this gloss value are very rare and usually have a lower ratio it is obvious that the danger of crazing due to too much silica in the sewer pipe clays is very slight and that silica can be added to the majority of clays without danger of causing crazing of the glazes.

In the place of equations 2, 3 and 4 the following equations 5, 6 and 7 may be used, which although not as accurate as the first equations are much simpler and within the limits covered in this investigation are sufficiently close for practical purposes:

$$R_1 = (0.162 + 0.018x_3)x_3 + 2.66 \quad (5)$$
$$R_2 = (0.105 + 0.005x_3)x_3 + 1.70 \quad (6)$$
$$R_3 = (0.48 + 0.12x_3)x_3 + 5.30 \quad (7)$$

The limits of the ratios of per cent silica to per cent alumina plus iron oxide between matt, semi matt and bright glazes are given by the following expressions for glazes of varying silica, alumina and iron oxide contents.

Glossiness of the salt glaze	Ratios of per cent silica to per cent alumina plus iron oxide
Matt	<1.20 to $(0.105 + 0.005x_3)x_3 + 1.70$
Semi Matt	$(0.105 + 0.005x_3)x_3 + 1.70$ to $(0.162 + 0.018x_3)x_3 + 2.66$
Bright	$(0.162 + 0.018x_3)x_3 + 2.66$ to $>(0.48 + 0.12x_3)x_3 + 5.30$

The glazes were divided into 15 groups according to their color and brightness (Fig. 3). The limits in composition of these are given in Table I.

The Effect of Variable Silica, Alumina and Iron Oxide in Clays on the Thickness of Glaze and Vitrified Surface Produced by Salt Glazing.—The 36 glazed trial pieces were split in two and the thicknesses of the glazes measured under a microscope. When thus examined the K series which contained practically no iron oxide showed a sharp division line between the glassy glaze and the crystalline body, making it easy to measure the thickness of the glaze. The results of the measurements of the thicknesses of glazes in this series are shown in Fig. 4. It is obvious that raising the silica content in clays increases the thickness of the resultant salt glaze to a marked extent. This thickness

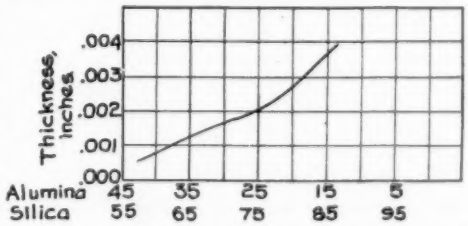


FIG. 4.—The effect of variable silica and alumina in clays on the thickness of glaze produced at cone 3, 1190°C, 2174°F.

[1] R. T. Stull, "Influence of Variable Silica and Alumina on Porcelain Glazes," *Trans. Amer. Ceram. Soc.*, **14**, 62 (1912); H. H. Sortwell, *loc. cit.*

TABLE I

LIMITS IN COMPOSITION OF CLAYS WHICH WILL PRODUCE DIFFERENT SALT GLAZES

Description	Limits of iron oxide (Fe_2O_3), per cent	Ratio of per cent silica to per cent alumina plus iron oxide in clay	Gloss factor
A. Dark brown to black bright glazes	8.2 to > 12.33	$(.162 + 0.018x_3)x_3 + 2.66$ to $> (0.48 + .12x_3)x_3 + 5.30$	0 to > 0.1576
B. Mahogany bright glazes	4.75 to 8.20	$(.162 + 0.018x_3)x_3 + 2.66$ to $> (0.48 + .12x_3)x_3 + 5.30$	0 to > 0.1576
C. Brown bright glazes	3.50 to 4.75	$(.162 + 0.018x_3)x_3 + 2.66$ to $> (0.48 + .12x_3)x_3 + 5.30$	0 to > 0.1576
D. Light brown bright glazes	1.00–2.19 to 3.50	$(.162 + 0.018x_3)x_3 + 2.66$ to $> (0.48 + .12x_3)x_3 + 5.30$	0 to > 0.1576
E. White to tan bright glazes	0 to 1.00–2.19	$(.162 + 0.018x_3)x_3 + 2.66$ to $> (0.48 + .12x_3)x_3 + 5.30$	0 to > 0.1576
F. Dark brown to black semi matt glazes	8.2 to > 12.33	$(.105 + 0.005x_3)x_3 + 1.70$ to $(.162 + 0.018x_3)x_3 + 2.66$	—.1337 to 0
G. Mahogany semi matt glazes	4.75 to 8.20	$(.105 + 0.005x_3)x_3 + 1.70$ to $(.162 + 0.018x_3)x_3 + 2.66$	—.1337 to 0
H. Brown semi matt glazes	3.50 to 4.75	$(.105 + 0.005x_3)x_3 + 1.70$ to $(.162 + 0.018x_3)x_3 + 2.66$	—.1337 to 0
I. Light brown semi matt glazes	1.00–2.19 to 3.50	$(.105 + 0.005x_3)x_3 + 1.70$ to $(.162 + 0.018x_3)x_3 + 2.66$	—.1337 to 0
J. White to tan semi matt glazes	0 to 1.00–2.19	$(.105 + 0.005x_3)x_3 + 1.70$ to $(.162 + 0.018x_3)x_3 + 2.66$	—.1337 to 0
K. Dark brown to black matt glazes	8.2 to > 12.33	< 0.98 to $(.105 + .005x_3)x_3 + 1.70$	< —.24 to —.1337
L. Mahogany matt glazes	4.75 to 8.20	< 0.98 to $(.105 + .005x_3)x_3 + 1.70$	< —.24 to —.1337
M. Brown matt glazes	3.50 to 4.75	< 0.98 to $(.105 + .005x_3)x_3 + 1.70$	< —.24 to —.1337
N. Light brown matt glazes	1.00–2.19 to 3.50	< 0.98 to $(.105 + .005x_3)x_3 + 1.70$	< —.24 to —.1337
O. White to tan matt glazes	0 to 1.00–2.19	< 0.98 to $(.105 + .005x_3)x_3 + 1.70$	< —.24 to —.1337

was increased about 600% by raising the silica content from 54 to 85.33%.

In examining the trial pieces containing considerable iron oxide it was observed that there was a black vitrified area underneath the glazes. The thickness of this black portion increased with the iron oxide content. It was difficult to distinguish between the glass and this black vitreous area which encased the entire test piece and therefore the total thickness of vitrified casing plus salt glaze produced was measured and the results are shown in Fig. 5.

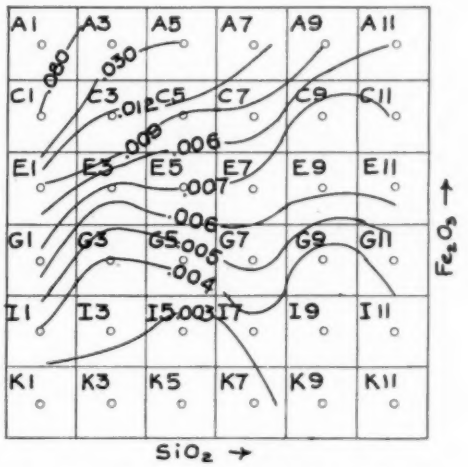


FIG. 5.—The effect of variable chemical composition of clays on the thickness of the vitrified surface and glaze produced by salt glazing.

Since the thickness of the vitreous casing underneath the salt glaze becomes greater with an increase in iron oxide we find that glazes in area *K*, (Fig. 3) have the largest values for the sum of vitrified casing plus glaze. Since the color of this vitreous casing is black it probably exerts an important influence on the color of the more or less transparent glazes.

The Relation between Geological Ages of Clays and the Type of Salt Glaze Produced

In Table II is shown the relation between the geological age and the type of salt glaze predicted for some clays. The letters A to O represent the different areas (Fig. 3) in which the glazes produced by these clays lie. These results show that there is no definite relation between the geological age and the type of glaze obtained since clays in the same geological age may vary from those highly desirable for sewer pipe glazes to others unsuitable for the production of salt glazes. (Table II.)

TABLE II

	Bright					Semi matt					Matt				
Geological Age	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
Lower Carboniferous					2						3	2			1
Coal Measures		2	2	2	3		3	1	3	4	5	2	1	2	1
Residual					1	1			1	1	1			1	2
Pleistocene							3					2			
Lower Kittaning										1					1

Summary and Conclusions

The effects of variable silica, alumina and iron oxide on the ability of different clays to take a salt glaze were studied. The salt glazing was performed at cone 2, 1170°C, 2138°F, in a commercial sewer pipe kiln under normal conditions. The limits given below would vary considerably if salting was done under strongly reducing conditions and at a different temperature than that given above.

Although the results apply in general to most clays, strictly speaking they only hold true with clays in which the chief constituents are alumina, silica and iron oxide, with the other impurities totaling less than 1.4 per cent and where all minerals are finer than 100-mesh size.

1. Theirs is a closer relation between color of salt glazes and the per cent iron oxide in clays than between the color and the molecules of iron oxide as used in ceramic formulas for glazes.

2. Black to dark brown glazes are obtained when the clays contain more than 8.2% iron oxide in terms of calcined weight.

3. Mahogany glazes are produced when the clays contain 4.75–8.2% iron oxide in terms of the calcined weight of clay.

4. Brown glazes are obtained when the clays contain 3.5–4.75% iron oxide in terms of calcined weight of clay.

5. Light brown glazes are produced when the clay contains 1.00–2.19 to 3.5% of iron oxide in terms of calcined weight of clay.

6. White to tan glazes are obtained when the clay contains 0 to 1.00–2.19% iron oxide in terms of the calcined weight of clay.

7. The glazes were divided into three groups and are designated as bright, semi matt and matt glazes. The ratios of per cent silica to per cent alumina plus iron oxide bear the closest relation to these areas which fall between the following limits of these ratios:

Matt glazes = <1.20 to $(0.105 + 0.005x_3)x_3 + 1.70$
Semi matt glazes = $(0.105 + 0.005x_3)x_3 + 1.70$ to $(0.162 + 0.018x_3)x_3 + 2.66$.
Bright glazes = $(0.162 + 0.018x_3)x_3 + 2.66$ to 5.30

8. Gloss values were determined for alumina, silica and iron oxide from which a gloss factor of the glaze produced by a similar clay may be calculated by means of a formula from its chemical analyses as follows:

$$x_1g_1 + x_2g_2 + x_3g_3 = 100G.$$

In this equation x_1, x_2 and x_3 are the percentages alumina, silica and iron oxide, respectively, in the clay in terms of calcined weight and g_1, g_2 and g_3 are gloss factors for alumina, silica and iron oxide, respectively. The gloss factor for Al_2O_3 is —1.00; for SiO_2 is 0.376; and for Fe_2O_3 is —2.923.

When the composition of a clay is such that $G = -0.24$ to -0.1337, the glaze is matt; when $G = -0.1337$ to 0 the glaze is semi matt; and when $G = 0$ to <0.1576 the glaze is bright.

9. The glazes produced by clays of varying compositions were divided into 15 groups as follows: (1) Dark brown to black bright glazes, (2) mahogany bright glazes, (3) brown bright glazes, (4) light brown bright glazes, (5) white to tan bright glazes, (6) dark brown to black semi-matt glazes, (7) mahogany semi-matt glazes, (8) brown semi-matt glazes, (9) light brown semi-matt glazes, (10) white to tan semi-matt glazes, (11) dark brown to black matt glazes, (12) mahogany matt glazes, (13) brown matt glazes, (14) light brown matt glazes and (15) white to tan matt glazes.

10. Increasing the silica content of low silica clays increases the thickness of the resultant salt glaze as high as 600%.

11. Clays containing considerable iron oxide had a black casing of vitreous clay underneath the glaze which encased the entire test piece.

12. The geological age of a clay bears no close relation to the type of salt glaze it will take.

NOTE: In conclusion the writer wishes to acknowledge his indebtedness to Dr. E. W. Tillotson for helpful advice during the progress of the work and to the courtesy of The Patton Clay Manuf. Co., Patton, Pa., and The Pennsylvania Clay Products Co., West Winfield, Pa., at whose plants these tests were conducted.

WASHING TESTS OF GEORGIA CLAYS[1]

By R. T. Stull[2] and G. A. Bole[3]

ABSTRACT

The Whirlpool Classifier.—A device is described by which the impurity in a clay can be separated more efficiently than is possible by simple elutriation processes.

Washing Plants.—A semi-commercial plant used to wash 1000-lb. samples is described, together with a suggested plan for a commercial plant.

Beneficiation of Georgia Clays.—Results obtained on several Georgia sedimentary clays are given. The washed clays are reported free from grit and material producing specks in burned ware as well as improved in color, both in the raw and burned state.

Introduction

The amount of English china clay normally used in the United States prior to 1920 amounted approximately to $1^1/_2$ times the annual domestic production. The English china clay is used mostly in the production of the better grades of pottery, paper, and oil cloth.

The users of English china clay say that it is more dependable than the majority of domestic clays on account of its uniformity, a point which the American producers should strive to attain if they are to compete with the foreign product. In pottery it appears to give, as a rule, better color and working properties and produces a higher per cent of sound ware. In the paper and oilcloth industries, the English clay seems to give better spreading qualities and to produce less wear upon the machinery. These desirable properties of the English clays are, to a degree, due to their careful washing and blending.

An oilcloth manufacturer reports that it is only necessary to grind his spreading knives twice a week when using English clays, whereas it is necessary to grind them twice daily when using American clays. The principal objection to American clays, therefore, seems to be that they contain considerable "gritty" or abrasive material which, if removed, would give a more uniform product of better plasticity and working properties and in many cases, a whiter burning product.

The gritty material in kaolin may be composed of a number of different minerals, chief among which are quartz, mica, rutile, and partly weathered feldspar, besides iron bearing minerals detrimental to color.

Separation of Coarse Grit.—In the clay washing process where the separation is made by flowing the clay slip in troughs or sluices, considerable fine granular material and thin mica flakes are carried over with the clay, a large per cent of which passes through the screens. The degree of separation with respect to size of the particles depends upon the force

[1] Published by permission of the Director, Bureau of Mines. Work done in coöperation with the Central of Georgia Railway Co.

[2] Supervising Ceramist.

[3] Superintendent, Ceramic Experiment Station.

of gravity acting against the carrying power of the water due to its velocity of flow.

Inasmuch as the force of gravity is constant, the degree of separation can be governed by regulating the velocity of flow. The fine granular material in settling carries down more or less clay substances even though the clay has been deflocculated and the quantity thus lost increases rapidly with the decrease in the velocity of flow and decrease in the size of particles settling. To remove the fine abrasive material passing the 120-mesh screen which causes excessive wear on paper and oilcloth machinery, it would be necessary to slow down the flow to such an extent that the loss of clay carried down with the grit would be excessive.

Separation of the Finer Grit.—Nearly everyone has observed on dissolving salts in a beaker of water by stirring with a glass rod, that upon removal of the stirring rod, the grains of undissolved salt will move rapidly in a spiral path toward the center of the beaker and concentrate in the form of a flat cone on the beaker bottom.

It was thought that this "center seeking" principle observed in the whirling liquid in the beaker might be adapted to the claywashing process for removing the fine grit and mica. The operating principle of the cyclone dust separator is somewhat similar.

Part I.—The Whirlpool Classifier

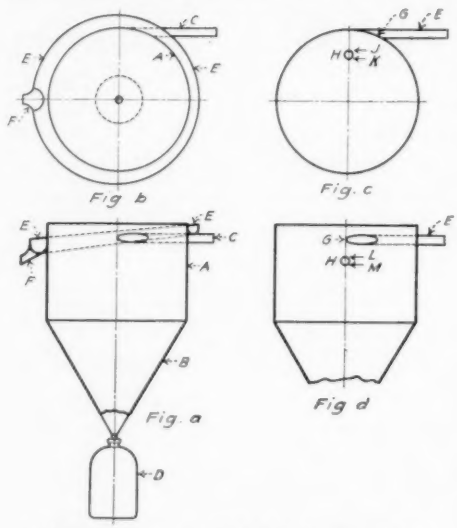
The Classifier.—The clay separator herein described differs from the air separator more particularly in that the conveying medium is water instead of air. The separation of the coarser from the fine and colloidal particles is effected by producing a whirlpool motion in the clay slip in a stationary cylindrical vessel. The separator has therefore been called the "Whirlpool Grit Separator" or the "Whirlpool Classifier."

Fig. 1*a* shows the elevation and Fig. 1*b* the plan of one of the first separators used in the preliminary experiments. The cylindrical portion *A* was 12 inches in diameter and 8 inches high. The height of the collecting cone *B* at the bottom was 10 inches. The cylindrical portion of the separator was provided with a tangential spout *C* near the top for the inflow of the clay slip. The clay slip, flowing in tangentially from a constant head, sets up a "whirlpool" motion, causing the coarser particles to be carried to the center and downward, where they are collected at the bottom of the cone in a connected flask *D*. The very fine clay particles float with the water out over the top into a trough or launder *E* and flow out the spout *F*.

Basic Principle of Whirlpool Classification.—To observe the path of travel of a particle, consider that the liquid in the separator Fig. 1*c* is made up of an infinite number of concentric rings. The liquid flowing in tangentially through the spout at *G* causes the different rings to rotate at different angular velocities. A ring of liquid near the wall of the can

has the highest angular velocity or r.p.m.[1] The angular velocity of each successive ring diminished toward the center of rotation due to the "slippage" or lag effect of each successive ring.

Let H be a granular particle large enough to be acted upon by the differential of forces. Also let the arrows J and K, Fig. 1*c*, represent the magnitude of the forces of two liquid rings, produced by the different angular velocities. The force J acting upon the outer edge or point of H farthest from the center of rotation is of greater magnitude than the force K acting on the point of H nearest the center of rotation. These unequal and parallel forces acting in the same direction on opposite sides of the particle H cause it to rotate in a horizontal plane.



FIGS. 1*a*, *b*, *c*, *d*.—Whirlpool separator.

The point about which the particle H rotates is not its center but a constantly changing point between its center and the center of rotation of the liquid rings. This off-center rotation of H, together with its forward movement, causes it to travel in a spiral path to the center of the cylinder. As H travels from the point of inflow to the center, it is continuously passing from rings of higher to lower angular velocity. Its rate of travel, therefore, diminishes as it approaches the center of the cylinder.

At the same time that the unequal forces are crowding H toward the center of the cylinder, unequal and parallel forces are also acting upon it together with gravity, to force it downward.

Not only may we consider that the liquid with its suspended particles consists of an infinite number of concentric rings horizontally, but we may also consider that it is made up of an infinite number of discs or layers vertically, Fig. 1*d*. A disc of liquid opposite the inflow at G travels at the highest velocity and the velocity diminishes in each successive layer below, due also to the lag effect.

Since the disc of liquid on top of the particle H is rotating at a higher rate than the layer on its lower side, the force L acting on top of H is of greater magnitude than the force M acting on its lower side. These

[1] The liquid rings in contact with the wall of the separator are retarded by friction. Those of highest angular velocity are a short distance away from the wall.

unequal and parallel forces, therefore, cause H to rotate vertically about a point below its center which causes it to travel downward, assisted of

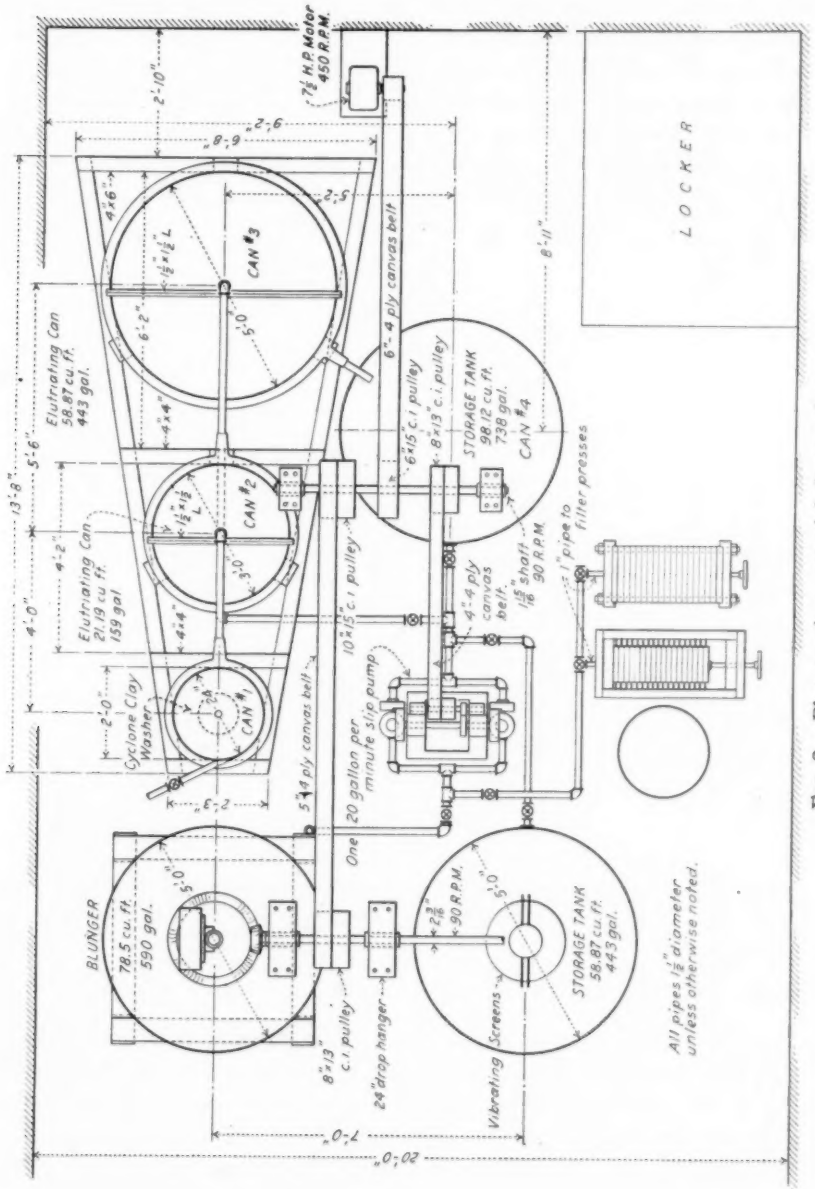


FIG. 2.—Plan, semi-commercial clay washer.

course by gravity. Its fall is rapid at first and decreases as it descends into layers of lower and lower r.p.m.

Large particles travel to the center and downward more rapidly than small ones because the differential of forces acting upon their opposite sides is greater. As the size of the particle diminishes, the difference between the magnitude of the forces acting upon it diminishes. As the diameter of the particle approaches zero, the difference in magnitude of the forces acting upon it approaches zero. However, before the theoretical zero size of particle is attained, a size occurs whose diameter is such that its center seeking force is over-balanced by the small centrifugal force as-

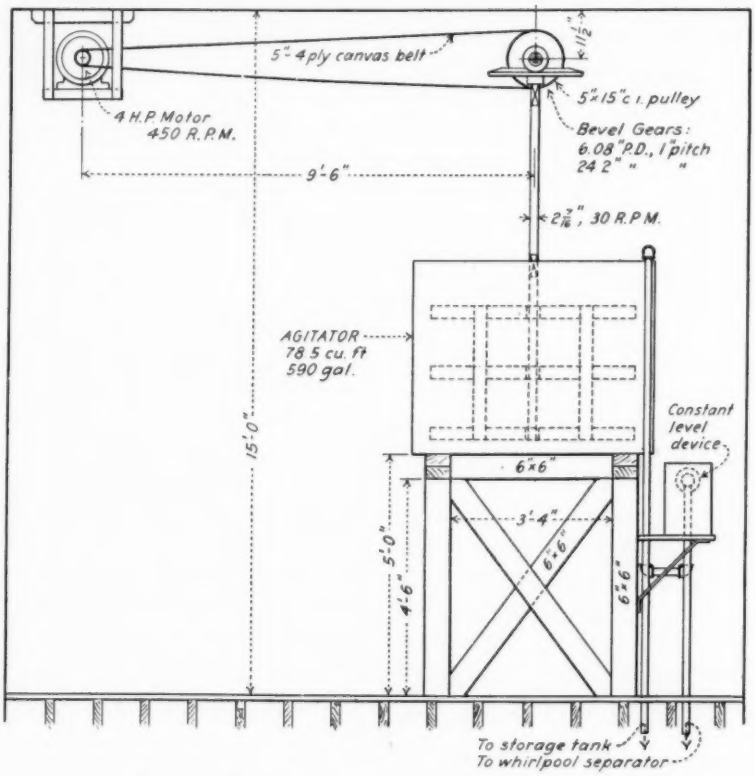


FIG. 3.—Elevation, semi-commercial clay washer.

sisted by the carrying power of the liquid. The particle, therefore, travels with the liquid and substantially as a part of it, and finally passes out over the top of the cylinder into the trough E and passes out of the spout F, Fig. 1*a*.

Experimental Test of Whirlpool Classifier.—Preliminary tests were made with 15-pound samples of Georgia kaolin previously washed at the mines. The clay was prepared in slip form consisting of 90 per cent water and 10 per cent clay by weight and deflocculated with caustic soda.

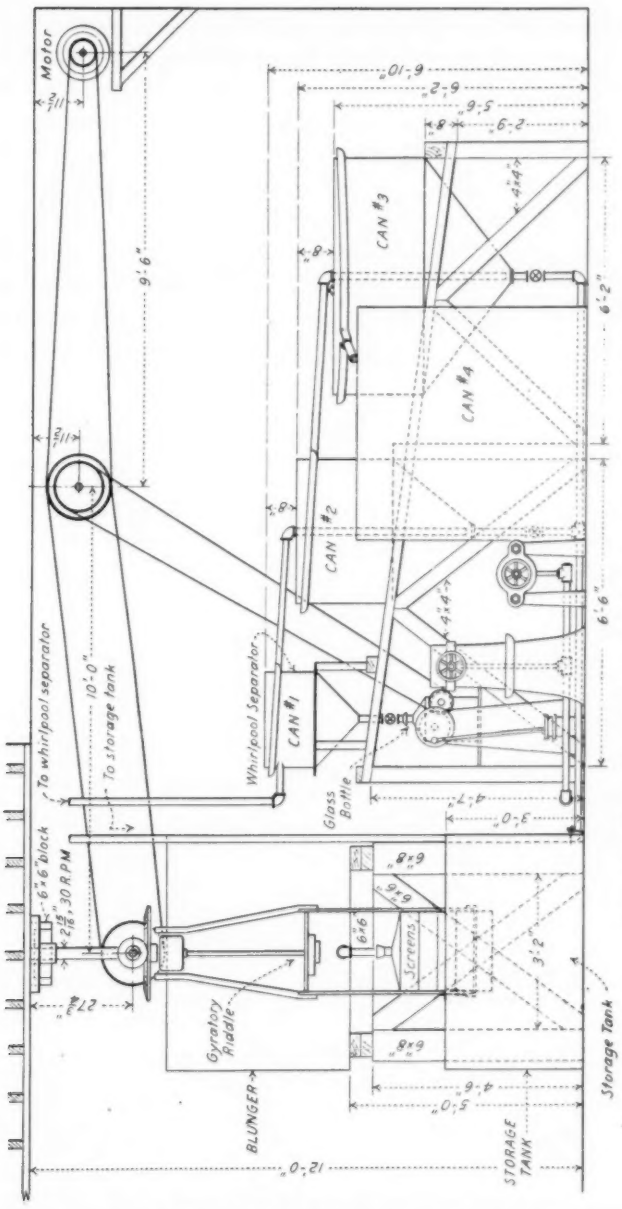
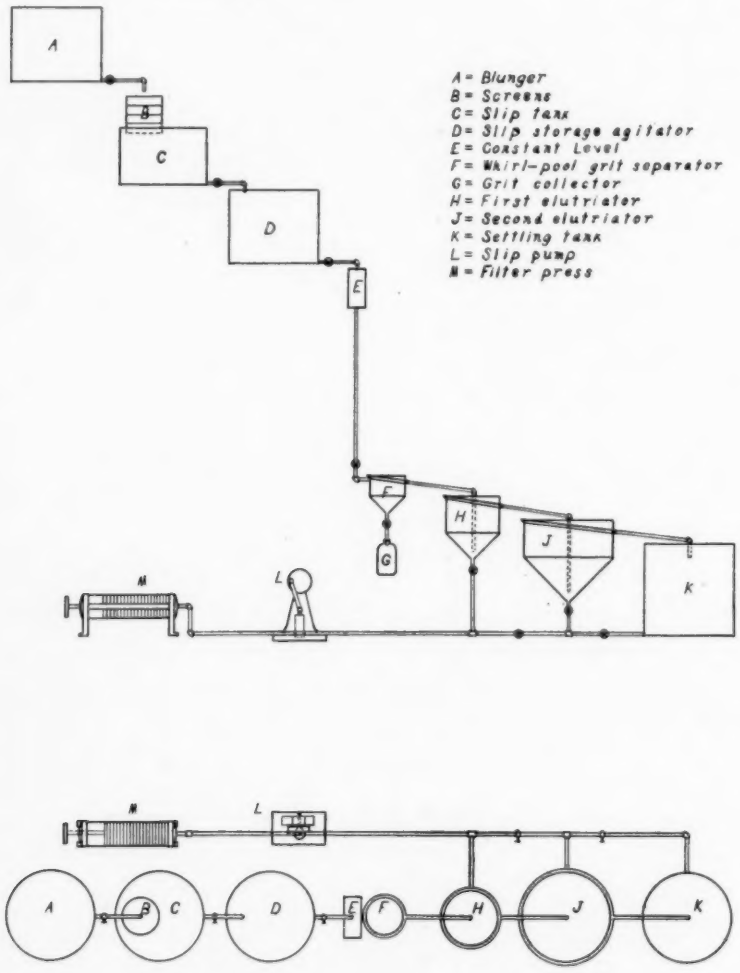


FIG. 4.—Elevation, semi-commercial clay washer. (See Fig. 3.)[1]

The separator was first filled with clear water and the clay slip passed in from a constant level tank at an elevation of 15 feet, the inflow being regulated by a valve. After the clay slip had passed through, clear water was run through until the overflow became clear.

[1] Figs. 3 and 4 are part of the same elevation.

The grit collection in the flask was removed, dried and weighed. The average grit removed from five tests was 6.09%. This consisted principally of silica grains and mica with some coarse kaolin grains and fine brown particles of rutile.



FLOW SHEET, CLAY WASHER —

FIG. 5.—Conventional flow sheet.

Semi-Commercial Washing Plant.—The coöperation between the Bureau and the Central of Georgia Railway Company made it possible to try out the whirlpool grit separator on a semi-commercial scale. A

washing plant designed to take care of a thousand-pound batch was constructed, using the same principle as that described above. The blunger A was 4 feet in diameter and had a capacity of 600 gallons. The whirlpool separator F was 2 feet in diameter, and the two elutriators H and J, 3 and 5 feet, respectively. The settling tank K was 6 feet in diameter and had a capacity of approximately 1000 gallons. L is a pump capable of feeding the slip to the filter presses M at a pressure of 65 pounds.

The plan and elevation of the set-up, drawn to scale, together with appropriate legends, is shown in Figs. 2, 3, and 4. A conventional flow sheet is shown in Fig. 5 to which the letters in the above description refer.

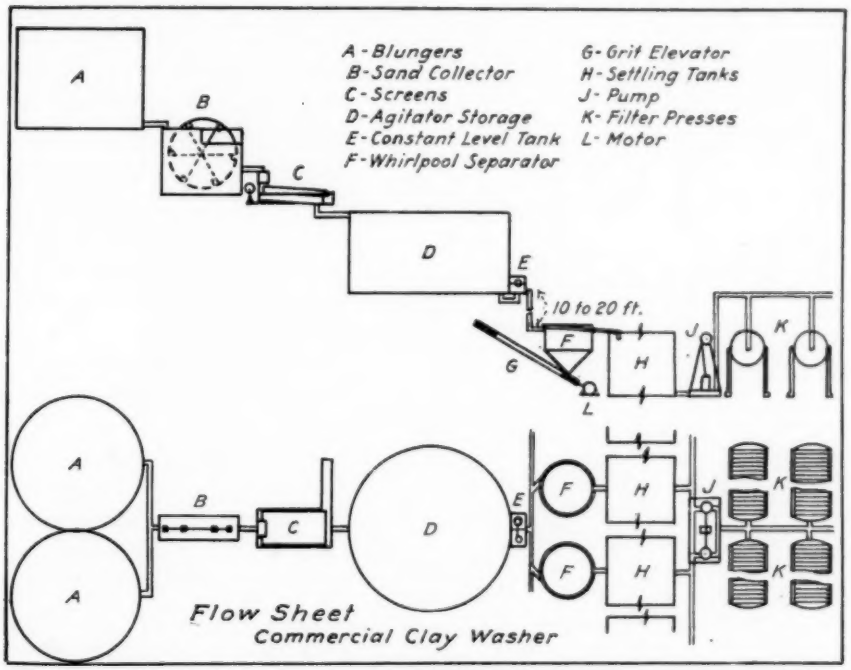
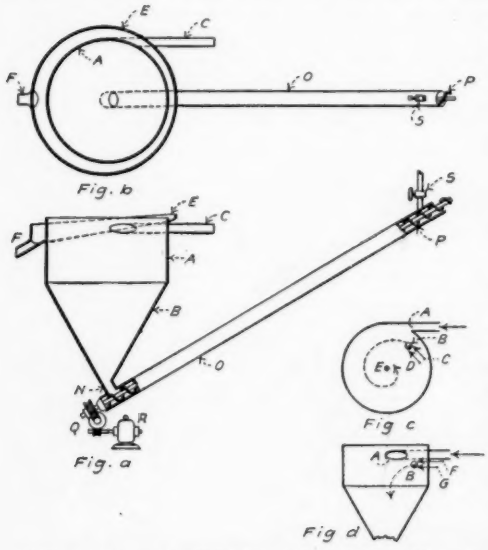


FIG. 6.

Since the capacity of the blunger was just about large enough to take care of 500 pounds of clay when blunged to a slip of 15% solids by weight, the slip, after being thoroughly blunged with the appropriate amount of electrolyte, was run through a nest of screens, suspended in a gyratory riddle and stored in tank D where it was agitated until an additional charge of 500 pounds was blunged and ready to be run through the washer. The valve leading from the agitator to the constant level tank E was then opened and the charge run through the washer at the rate of about 2.5 gallons per minute. When the slip was run, an attempt was made to get as much through the system as possible before starting the water for

washing. It was the aim to wash until the several cans were clear, but it was not possible in all cases on account of the limited capacity of the outfit. A large amount of experimentation proved that the rate at which the clay was run through the washer could be varied considerably without materially changing either the quantity (per cent) or quality of the recovery in the settling tank.

Suggested Commercial Plant.—A flow sheet for a commercial plant is suggested in diagrammatic form in Fig. 6. In the proposed outfit are two blungers *A* in order to make the operation continuous. The coarse grit is removed by the sand wheel *B*. From the sand trough the slip flows over the mechanically agitated hundred mesh screen *C* and into the agitator *D*. The flow into the whirlpool separators *F* is regulated by a constant level tank *E*. There is provision made for as many whirlpool separators as the capacity may demand. Extra units may be added from time to time. The grit elevator *G* which is operated by the motor *L*, delivers the coarse material at the level of the overflow from *F* to a dump.



FIGS. 7*a*, *b*, *c*, *d*.—Whirlpool separator with grit elevator.

As many settling tanks *H* are provided for as the capacity may demand. The pumps *J* serve to deliver the concentrated slip to the filter presses *K*. Electrolyte is added to the blungers in order to float the clay, the amount being previously determined by laboratory tests. The slip is flocculated in the settling tanks by the addition of acid. Such an outfit can be depended upon to deliver to the presses approximately 70% of the clay charged when Georgia sedimentary clays are being washed.

A detail drawing of the whirlpool classifier with grit elevator is shown in Fig. 7*a*, *b*, *c*, and *d*. The designs are the same as those in Fig. 1 with the exception that a grit elevator has been substituted for the glass bottle *D*. In Fig. 7*a* (*O*) is a metal tube the length and diameter of which will vary with the capacity of plant and the clay being washed.

A motor (*R*) driven worm (*P*) is operated at such a speed as to remove the grit from the cone of the classifier. By proper gears (*Q*) the rate at which the material will be removed can be controlled. Wash water

is admitted at (*S*) in order to wash the ascending column free from clay.

The capacity of a classifier in pounds per hour figured on a dry basis, is governed by the density of the slip and the rate at which it is delivered.

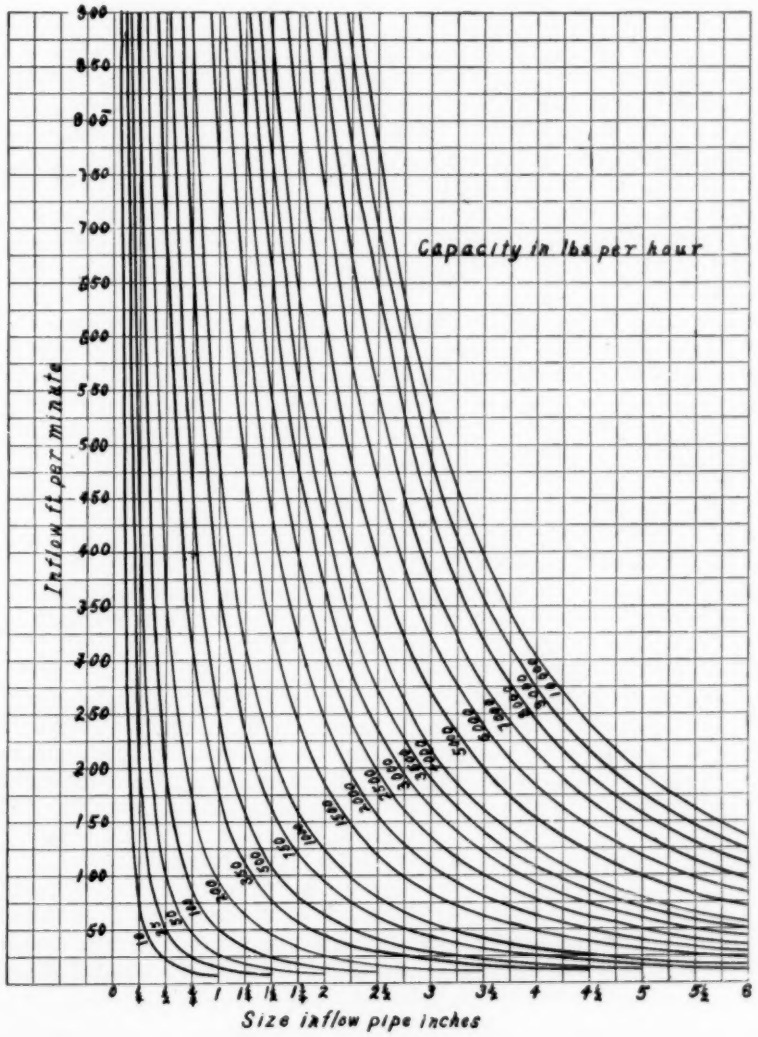


FIG. 8.—Capacity of grit separator.

In Fig. 8 diameter of inflow pipe is plotted against rate of flow. The figures are based on a slip containing 10% clay. A rough idea of the dimensions required for a classifier of desired capacity can be gained from the curves.

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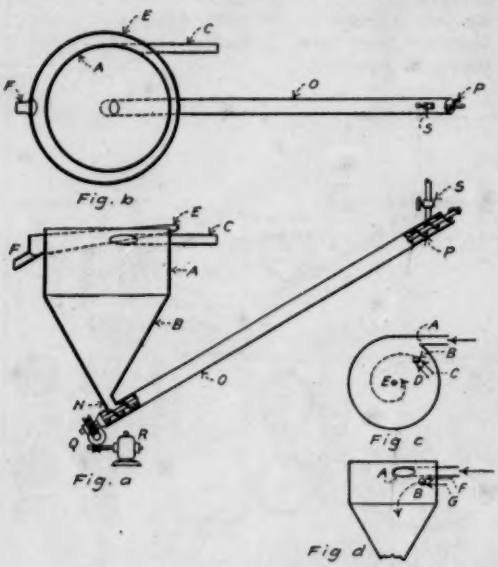

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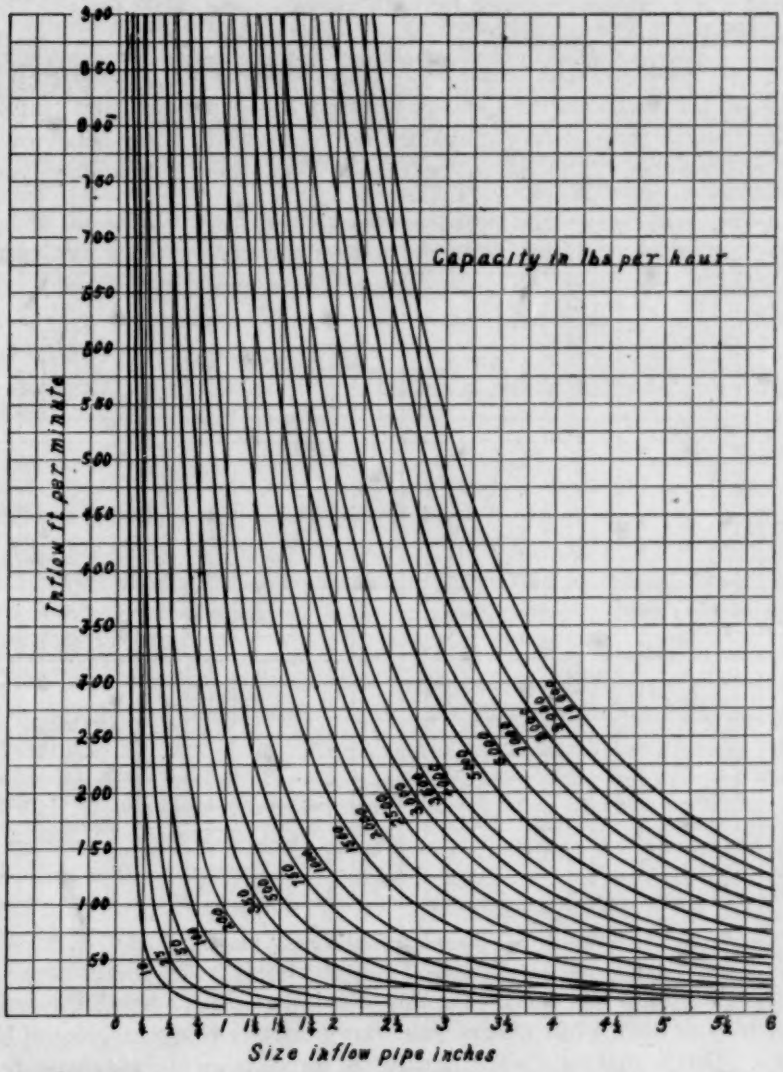

FIG. 8.—Capacity of grit separator.

In Fig. 8 diameter of inflow pipe is plotted against rate of flow. The figures are based on a slip containing 10% clay. A rough idea of the dimensions required for a classifier of desired capacity can be gained from the curves.

Part II.—The Washing of Georgia Clays

Deflocculation.—The quantity of electrolyte necessary to be added to the slip in order to deflocculate the clay and later to flocculate it, using distilled water, was determined by both viscosity and settle tests. These methods have been described so often in the literature that any further description is not thought necessary. If the reader is not familiar with the details of the methods used, he is referred to Bleininger[1] and Sproat.[2]

The Georgia sedimentary clays are not uniform in their behavior toward electrolytes. This is to be expected as their colloidality varies

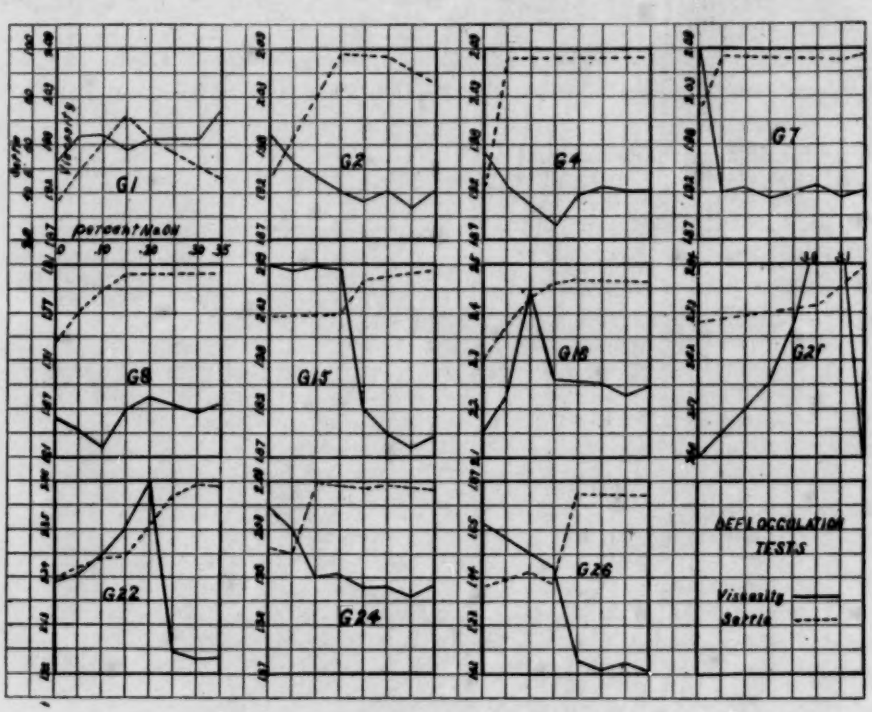

FIG. 9.—Deflocculation and settle curves.

greatly. Some of the clays were not affected at all by small amounts of either base or acid, while others were very sensitive to electrolytes of both classes. Settle methods were hardly so satisfactory as viscosity determinations for some of the clays, as a small amount of a highly colloidal material stays in suspension much longer than the body of the material, thus giving misleading values.

The quantity of electrolyte required varies enormously with the dif-

[1] *Trans. Amer. Ceram. Soc.*, **14**, 827 (1912).

[2] U. S. Bureau of Mines, *Bull.* **128.**

ferent clays. In a few cases, the clays are so highly deflocculated by blunging with distilled water that the addition of alkali distinctly raises the viscosity. One of the clays was especially difficult to handle because of the fact that neither acid nor base had the slightest affect upon it.

Sodium hydroxide was used as the deflocculant and acetic acid as the coagulant. A comparison of the viscosity and settle tests on a few of the clays, using distilled water, is shown in Fig. 9.

Results of Washing.—It was not in all cases possible to tell from preliminary tests whether a clay would wash to a good white either raw or burned, so all the clays that gave any promise of being satisfactory for either the filler or whiteware trade were run through the washer. A small sample of the overflow was dewatered in each case and if the raw and fired clay proved not at all satisfactory as to color all but a small sample of the slip was run into the sewer. If the color tests proved satisfactory the entire charge was dewatered.

Eighteen samples proved to be suited to the filler trade after washing. Three hundred-pound samples of each of these clays were sent to the Southern Station of the U. S. Bureau of Mines to be later tried out commercially in the filler trades. A report on this phase of the work will be made at a later date.

The fire tests showed that seven of the washed samples burned to a sufficiently good white to justify trying them out in the whiteware trade. The results of tests made on these clays will be reported in the next of this series of articles.

The burned color of most of the clays was greatly improved by washing. However, two of the number burned to a poorer white than the crude clay. The degree to which any clay can be purified by this method of washing depends upon two factors, (1) the degree to which the clay will disperse, and (2) the specific gravity of the dispersed particles. If the impurity in a clay is of a low specific gravity or if it is in a colloidal state of subdivision, or a combination of the two, it will be carried over into the settling tank. The whirlpool classifier seems to separate mica flakes more efficiently than a simple flotation process, due to a sort of diving effect brought about by the unbalanced forces acting on different parts of the flake. This effect causes the flakes to concentrate at the bottom and they are removed with the grit.

Dewatering.—The more finely divided clays filtered so slowly that methods other than filter pressing were tried. The thickened slip was run into large plaster of Paris troughs and dried. Heat was applied and fans used in an endeavor to hasten the evaporation of the water. The method was slow at best but gave better results on two of the more finely divided clays than did filter pressing.

A barrel of slip was run through a Dorr thickener and brought up to

a solid content of 32%, after which it was dewatered in a continuous disc vacuum filter. The cake contained 37% moisture as against 32 per cent in a pressure filter. The results obtained on this particular clay would seem to indicate that the method could be made an economic success.

The utility of a vacuum filter varies enormously with different clays. The more finely divided the clay, the slower the operation. If a cake one-eighth inch thick can be built up without slowing up the operation unduly, the system stands a chance of success. The dewatering of these clays will be taken up in a later paper.

Chemical and Microscopic Analysis of the Separates Obtained

In order to gain some idea of the efficiency of the washing process, chemical and microscopic analyses were made on each of the separates in the case of two of the clays selected for the whiteware tests. In the following table are shown the results of chemical analysis on one of these clays (G-7).

	Crude	Grit	Can 1	Can 2	Can 3	Can 4
Loss on Ignition	13.55	11.42	13.06	13.30	13.55	13.47
SiO_2	44.25	42.29	45.49	44.94	45.10	45.26
Al_2O_3	38.64	36.28	37.50	37.71	37.91	38.74
Fe_2O_3	1.45	3.45	1.35	1.39	1.27	1.32
TiO_2	1.62	5.79	1.86	2.15	1.75	.95
P_2O_5	.05	.02	.07	.05	.05	.02
CaO	.17	.22	.05	.17	.16	.25
MgO	.10	.36	.11	.12	.08	.02
K_2O	.13	.31	.39	.41	.26	.09
Na_2O	.29	.33	.30	.20	.15	.25
Sulphur	.02	.02	.01	.01	.01	.01
	100.27	100.49	100.19	100.45	100.29	100.38
$TiO_2 + Fe_2O_3$	3.07	9.24	3.21	3.54	3.02	2.27
Accessory Minerals	3.83	10.50	4.14	4.50	3.73	2.91

Clay G-7 showed the following screen and elutriation separates together with microscopic examination:

Separates	Percentage	Microscopic examination
On No. 8 screen	.195	The material on the various screens varied in size of grain rather than in the minerals present, consisting largely of a fine grained mineral having an index of refraction of 1.57 (probably bauxitic kaolinite). The accessory minerals included bauxite, quartz, zircon and black iron oxide.
On No. 20 screen	.310	
On No. 65 screen	.680	
On No. 100 screen	.242	
On No. 150 screen	.292	
Grit separate (bottle)	1.072	The most abundant mineral is iron-stained secondary kaolinite. A rather large amount of primary kaolinite is also present and the following in large amounts: quartz, zircon, rutile, biotite and black iron oxide. Tourmaline was found as a rare constituent.

Can No. 1 (whirlpool)	2.043	The most abundant constituent is secondary kaolinite. A rather large amount of primary kaolinite is also present. The accessory minerals occur in rather large quantities in this separate, zircon and muscovite predominate. A rather large amount of a black mineral, probably iron oxide, is present. Rutile, quartz and biotite occur in considerable quantities. A small amount of tourmaline is also found.
Can No. 2	1.950	This separate consists largely of iron stained secondary kaolinite. A rather large amount of primary kaolinite is also present. Considerable zircon, muscovite, quartz and rutile were found. Of these accessory minerals, muscovite predominated. A small amount of biotite and tourmaline was rarely found.
Can No. 3	10.400	This separate consists almost entirely of primary and secondary kaolinite. The secondary is iron stained and imparts a brown color to the clay. Only small amounts of fine-grained accessory minerals are present. Muscovite was found in the greatest quantity. Quartz, zircon, rutile, biotite and iron oxide were found in smaller amounts.
Can No. 4 (settle tank)	81.816	This separate consists almost entirely of primary and secondary kaolinite, the secondary kaolinite being much in excess of the primary. The secondary kaolinite is iron stained and imparts a slight brown color to the clay. Only very small amounts of fine-grained accessory minerals are present. Very small amounts of muscovite, quartz, zircon, rutile and black iron oxide composed the accessory minerals that were present.

COMPARATIVE CHEMICAL ANALYSES OF WASHED AND UNWASHED CLAY

	G-1		G-2		G-4		G-9	
	Crude	Washed	Crude	Washed	Crude	Washed	Crude	Washed
Ignition Loss	12.92	13.11	19.74	19.18	13.91		12.00	13.54
SiO_2	46.52	46.76	31.98	32.51	45.42		51.16	45.22
Al_2O_3	36.87	36.83	45.73	46.29	38.86		33.84	38.31
Fe_2O_3	1.47	1.44	.66	.54	.60		1.35	1.20
TiO_2	.77	1.36	1.68	1.40	1.36		1.16	1.44
P_2O_5	.05	.06	.07	.04	.03		.09	.09
CaO	.80	.15	.11	.14	.02		.30	.04
MgO	.30	.36	.17	.02	.12		.05	.13
K_2O	.43	.19	.00	.00	.00		.18	.17
Na_2O	.00	.00	.00	.11	.00		.12	.00
Sulphur	.02	.02	.04	.04	.02		.10	.02

	G-15		G-16		G-21		G-22	
	Crude	Washed	Crude	Washed	Crude	Washed	Crude	Washed
Ignition Loss	13.90	13.72	13.28	13.28	11.75	14.50	14.08	14.02
SiO_2	43.57	45.15	45.22	45.96	43.77	43.75	44.42	44.62
Al_2O_3	39.76	38.94	38.86	37.93	38.31	38.46	39.34	39.03
Fe_2O_3	.96	.72	1.02	.87	1.47	1.56	.60	.54

COMPARATIVE CHEMICAL ANALYSES OF WASHED AND UNWASHED CLAY (*Continued*)

	G-15		G-16		G-21		G-22	
	Crude	Washed	Crude	Washed	Crude	Washed	Crude	Washed
TiO_2	1.17	1.20	1.03	1.52	1.04	1.32	1.64	1.72
P_2O_5	.04	.03	.07	.06	.04	.06	.07	.07
CaO	.24	.11	.21	.05	.25	.02	.16	.08
MgO	.11	.02	.10	.26	.07	.08	.04	.10
K_2O	.16	.25	.51	.34	.17	.22	.00	.00
Na_2O	.38	.00	.08	.04	.13	.19	.02	.00
Sulphur	.15	.03	.02	.04	.16	.18	.06	.03

	G-24		G-26	
	Crude	Washed	Crude	Washed
Ignition Loss	13.35	13.90	13.20	13.76
SiO_2	48.23	45.35	45.27	44.99
Al_2O_3	35.60	37.23	38.78	38.62
Fe_2O_3	1.29	1.50	.81	.75
TiO_2	1.60	1.56	1.16	1.52
P_2O_5	.02	.02	.14	.13
CaO	.07	.16	.13	.07
MgO	.05	.07	.07	.17
K_2O	.00	.14	.02	.18
Na_2O	.04	.14	.49	.13
Sulphur	.01	.07	.01	.07

MECHANICAL SEPARATIONS OF WASHED CLAY

	G-2	G-4	G-15	G-16	G-24	G-26
On No. 8 screen	.20	...	.089	...	.387	...
On No. 20 screen	.50	...	.039	...	.268	...
On No. 65 screen	1.30	.635	.429	.20	1.362	.07
On No. 100 screen	.75	.185	.420	.20	1.100	.26
On No. 150 screen	.55	.140	...	...	...	...
Grit separate (bottle)	4.00	3.220	2.778	1.20	4.800	1.09
Can No. 1	5.00	2.190	1.857	1.50	...	1.24
Can No. 2	7.00	5.300	5.034	4.20	1.000	1.46
Can No. 3	9.00	17.930	8.364	17.20	8.900	18.80
Can No. 4 (settle tank)	71.70	70.400	80.990	75.50	82.183	77.08
	100.00	100.00	100.00	100.00	100.00	100.00

Description of the Washed Georgia Clays

Due to the variation of kind and amount of electrolytes in the Columbus city water, which was used for the semi-commercial tests, the results plotted in the graphs (Fig. 9) were not a safe guide from which to figure the amount of NaOH which should be added for deflocculation during the large batch washing as the results there plotted were obtained using distilled water. The viscosity of each clay is represented by a solid line and the amount remaining in suspension, termed "settle," by a dotted line.

Clay G-1.—Five hundred pounds of this clay were blunged and washed as described previously, using 0.24% NaOH. It was found necessary to carry on the blunging for 8 hours before the clay was completely disintegrated and ready to be put through the washer. The speed at which the washer was run was varied between 2 and 3 gallons per minute. Samples were collected during the several speeds after which color pats were made up and burned. As there was no variation in color apparent, it seemed safe to assume that the washer could be safely operated between these two limits. The color of the washed clay fired to cone 12 was a light gray and it gave little promise for use in the whiteware industry. Due to the finely divided character of the clay, some difficulty was experienced in filtering.

Clay G-2.—One thousand pounds of this clay were blunged using 0.24% NaOH. The raw clay was a good white color but contained a considerable quantity of bauxite nodules. The clay blunged very readily after deflocculation. In many respects this is a very peculiar clay as the chemical analysis shows it to be bauxitic in nature. In spite of this, however, it showed little more tendency to shrink during drying and burning than did the typical kaolins and exhibited other excellent working properties. Sedimentation was quite rapid, leaving a sticky residue in the bottom of the blunger which was difficult to remove during subsequent washing. On the addition of acid, the clay settled rapidly to a dense slip from which the water could easily be decanted. This clay was especially easy to filter press. The washed clay burned to a good white as did also a porcelain body containing 30%.

Clay G-4.—A one thousand pound batch of this clay was also blunged using 0.36% NaOH. The color of the raw clay was a good white but contained considerable material in the form of black specks. It slaked with difficulty and blunged slowly, 10 hours being required for the operation. A number of pebbles settled on the bottom of the blunger. Upon the addition of acid, the clay settled more slowly than did G-2 and formed a less dense slip, filtering was therefore somewhat slower. The washed clay burned to a good white and when made into a porcelain body the color was only slightly inferior to that of G-2.

Clay G-7.—A batch of one thousand pounds was blunged using .25% NaOH. The color in the raw state was only a fair white—microscopic examination showed it to be badly iron stained, only a portion of the stain was removed during washing. It blunged and filtered easily. The fire tests showed the color to be inferior to that of G-2 and G-4.

Clay G-9.—One thousand pounds were blunged using .20% NaOH. The color in the raw state was only a fair white—macroscopic examination showed it to contain many black specks. The clay blunged easily but filtered slowly. A sticky sediment was deposited in the bottom of the

blunger which was removed with difficulty. The fire tests of the washed clay were inferior in color to that of the raw clay, which fact seemed to be due to a colloidal iron. The color tests were so unsatisfactory that the clay was not tried out in the whiteware industry.

Clay G-15.—One thousand pounds were blunged and .3% NaOH used. The color of the clay in the raw state was a good white. It slaked readily thus cutting down the blunging time to 6 hours. No difficulty whatever was encountered during the washing. Due to the finely divided condition of the clay, filtering was somewhat slower than that of G-2. The fire tests gave a good white color which was comparable to G-4.

Clay G-16.—One thousand pounds of this clay were also blunged. This clay contains a little grit and was of an exceptionally good white color. Color samples of the crude clay burned to a good white but showed some black specks. No residue remained on screens No. 8 or No. 20. As indicated by the viscosity tests, this clay could be put into a high state of dispersion without the use of electrolyte. The clay blunged very easily and left little residue in the blunger. A predetermined quantity of acid was used to flocculate the clay. It settled rapidly and filtered very easily. The washed clay and porcelain bodies made from it burned to an excellent white, free from specks.

Clay G-21.—The same amount (1,000 pounds) of this clay was blunged. The color in the raw state was only fair. It blunged easily, was very finely divided, and fire tests showed the washed clay to be very little improved in color by operation. Since the clay gave no promise in the whiteware industry, only a small portion of it was filter pressed.

Clay G-22.—One thousand pounds were blunged using .3% NaOH. for deflocculation. The crude clay burned to a poor white, it slaked and blunged fairly easily but settled very slowly upon the addition of acid. As the fire tests on the washed clay were unsatisfactory, only a portion of the batch was dewatered. Due to the extremely fine subdivision of the clay, filter pressing was exceedingly slow.

Clay G-24.—One thousand pounds were also blunged using .3% NaOH This was the hardest clay to filter due to very finely divided material. It blunged very rapidly and a very sticky sediment settled in the blunger. The fire tests showed it to be somewhat better than G-22 but not sufficiently to justify trying out in whiteware practice.

Clay G-26.—The same amount of this clay was blunged using .25% NaOH. The color in the raw state was a fair white and burned to a good white. It slaked readily and no special difficulty was encountered during the washing. It filtered easily, comparing in this respect to G-2.

Discussion of Results

All the clays with the exception of G-22 and G-24 gave a better color

after washing than did the crude clays. These two clays exhibited a phenomenon similar to blue stoning. Many of the clays burned to a good white at cone 4 but developed a decided cream color at cone 12.

The color to which these clays will burn at cone 12 depends largely upon the ratio of the titanium and iron present. If the iron was low (.50%) and the titanium high (1.50%) or vice versa; the clay in most cases burned to a fair white. If the same total of iron and titanium was present, but each to the extent of 1%, the color was in every case poor. It is very probable that a titanate of iron is formed at the higher temperatures and causes the brownish tinge to which some of these clays burn above cone 8.

The washed clays containing more than 2% of titanium plus iron oxide failed to give a good color when fired to cone 12. The one exception was G-16.

The percentage of iron oxide found by chemical analysis is not so important in producing a variation from white as the form in which it is present. One of the clays which contained only .90% of iron and low titanium, developed a creamish tinge at cone 4, due to the fact that the iron was present as a stain on the kaolinite grains and was not removed by washing.

Conclusions

Based on data obtained during the investigation (*a*) it would seem that the Georgia sedimentary clays can be washed entirely free from dark burning material that caused specks in whiteware made from them; (*b*) that with proper blending and adequate storage space a uniform product can be put on the market; (*c*) that the burning color of the clays can be improved except in the case of those clays which contain their impurities in the form of collodial material or stain on the kaolinite grains. This was the case with only two of the white clays investigated.

EFFECT OF GROG ADDITIONS ON FIRE RESISTANCE OF HOLLOW TILE[1]

By Harry D. Foster

ABSTRACT

This paper mentions the general character of the investigation of the fire resistance of hollow tile and gives the results of only one phase of the work. A brief description of the test apparatus and the test method is given. Tests of three kinds of tile containing varying amounts of grog additions are described. These panels withstood the test for periods ranging from 20 minutes to six hours or more, the time varying indirectly with the grog content. It is concluded that the small grog additions which can be conveniently made in manufacturing practice have no effect, but that additions of five per cent or more will materially decrease the fire resistance of hollow tile.

The investigation of the fire-resisting and related properties of hollow building tile that is being conducted at the Bureau of Standards in cooperation with the Hollow Building Tile Association, consists of a series of tests of representative commercial load-bearing tile and also tests of tile embodying certain features intended as possible means of increasing fire-resisting properties. In the series here reported, the effect of additions of small percentages of grog (broken tile) to the tile clay was determined. Tests of tile from three different clays each containing no grog and $2^1/_2$, 5 and 10% were made.

The necessary 8 x 12 x 12 6-cell load bearing tile were donated by three manufacturers. They were made according to the usual routine except for the varying grog additions to the raw clay.

One of the three kinds of tile used in these tests was a typical shale. The manufacturer reported that his raw material was taken by means of a steam shovel from the open bank which had a face of 40 feet, the lower 10 feet being a medium hard blue shale, the next 20 feet, an olive colored shale not so hard as the blue and the balance of the bank, the olive shale more or less weathered. The second series of tile was made from an Ohio fire clay known as the No. 6 vein of fire clay found with the No. 6 vein of coal. The third series was made from a shale and fire clay mixture. This manufacturer reported that his raw material was obtained by means of a shale planer working on twenty-five foot face. The top 22 feet consists of a soft carboniferous shale and the lower 3 feet of a hard material, which, although not a true soapstone in the geological sense, is known in that part of the country as a soapstone. This formation overlies a vein of coal which in turn overlies a six to twelve foot vein of No. 2 fire clay. This clay is dug separately and is mixed with the shale in the grinding process. The grog used was in all cases kiln refuse or broken ware crushed to pass the same screens used for the raw material.

[1] Published by permission of the Director of the Bureau of Standards of the U. S. Department of Commerce.

All of the tile in each series were fired in various places in the same kiln. In this way tile representative of commercial ware were obtained and all factors contingent with laboratory work were avoided.

The test panels were laid up by an experienced mason working on contract basis. In order to duplicate prevailing conditions of practice the mason was allowed to use the mortar which he would normally use on an outside job. He chose a mortar of one part (by volume) of Portland cement, one part of lime and four parts of sand. After having made this choice the mortar was held to this proportion, the materials for each batch being accurately measured.

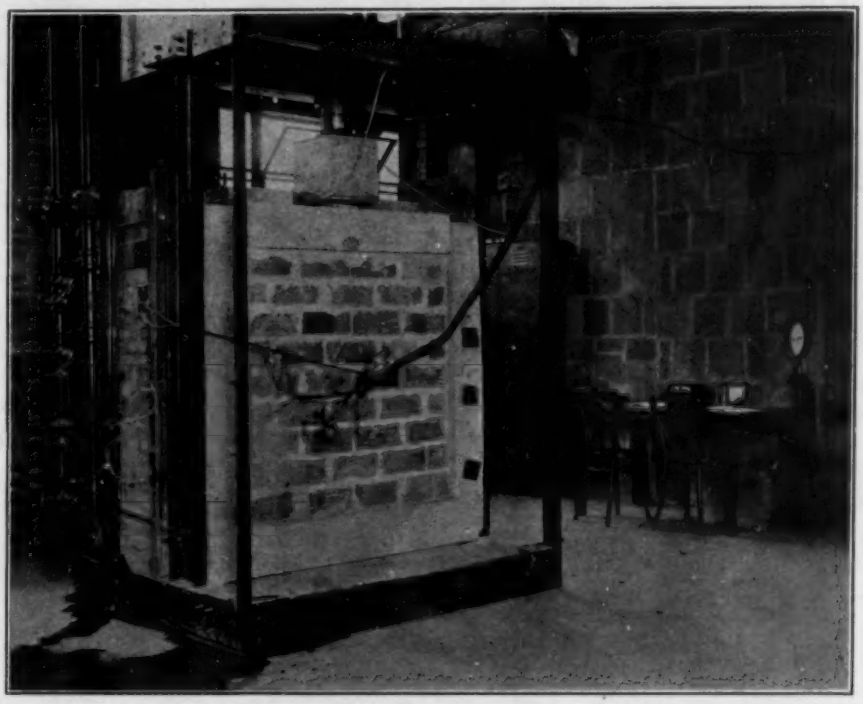

FIG. 1.—Testing furnace with panel prepared for testing.

All of the panels were aged 30 days before being tested. As these panels were built in the laboratory and during the summer, the best drying season of the year, it is believed that this aging period was ample.

The equipment necessary for conducting these tests consists of panel frames and crane for handling the test panels, a furnace for making the fire exposure, a restraining frame with hydraulic jack for loading the test panels, and a thermocouple installation for furnace control and for obtaining temperatures of the test panel.

Fifteen frames for holding test panels have been provided. Ten of these were built with their top member detachable, permitting loading of the panels. The remaining five were built solid so that the panel can be tested under restraint thus simulating a partition panel in buildings of fire-resisting construction.

The rear and two sides of the furnace (Fig. 1) are of brick construction, the front being closed by the test panel giving a combustion chamber two feet deep. Vent holes are placed in the crown of the furnace. The fuel used is gas taken from the city mains. By proper operation a temperature variation between different portions of the chamber of less than 20°C can be had except during the first half hour of the test.

The restraining frame is made of a heavy I-beam connected to the bottom member of the panel frame by channels serving as tension members. The load is applied by means of a calibrated hydraulic jack placed between this I-beam and the top member of the test panel frame.

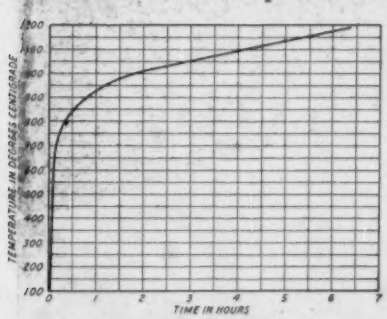

FIG. 2.—Time-temperature reference curve followed during fire tests.

All temperature measurements are made by the thermo-electric method. Six couples are used to measure the furnace temperature and three couples symmetrically arranged about the center of the test panel were placed in each set of cells of the wall. Three couples, of very fine wire, were similarly placed on the unexposed side of the test panel.

The material used in the couples is also used in the lead wires to the cold junction box (Fig. 1) which is kept at 0°C thus eliminating cold junction corrections.

A cathetometer mounted on a solid pier placed in front of the furnace is provided for measuring the vertical expansion of the test panel. Deflections are obtained by measuring from fine weighted wires attached to and stretched across the front of the panel frame.

The panels tested in the series under consideration were subjected to a constant working load and fire exposure increasing according to a predetermined time-temperature relation until failure occurred, with six hours as the limit of the fire exposure. The working load used in the tests was 120 pounds per square inch of gross bearing area. The time-temperature reference curve used is shown in Figure 2, and is the same as that now generally used in American fire test practice.

An accurate record was kept of the character of the fire and its effect on the test panel during all stages of the test. After the panel had cooled

it was torn out and notes on its general condition and the condition of each individual block were taken. Photographs were also taken of all panels after the test and a few typical panels before the test.

The period of time which a load-bearing wall is able to carry its load and hold back the fire and the salvage value of the wall after the fire, or in

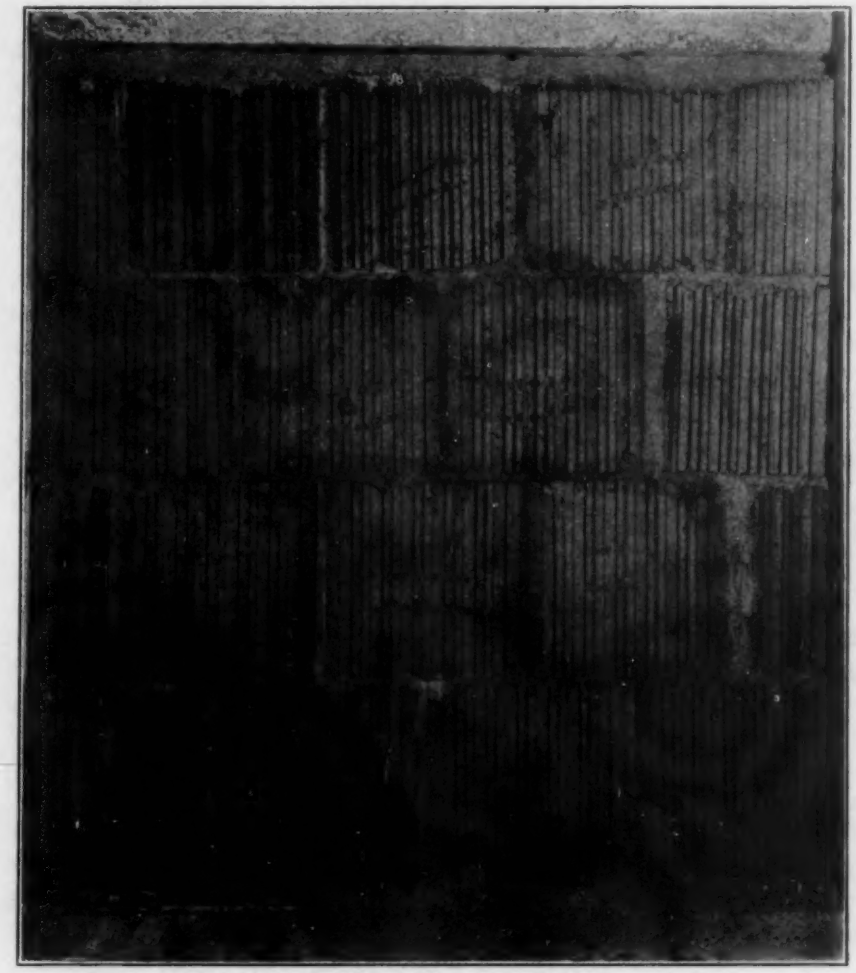

Fig. 3.—Exposed side of fire clay panel containing $2^1/_2\%$ of grog, after the fire test.

case fire-resistive interior construction is used, the extent of replacement necessary, serve as a criterion of the fire resistance of the panel being tested.

The panels of this series were able to carry their load from 20 minutes to 6 hours or more as follows:—

PERCENTAGES OF GROG ADDITIONS

	0	2½	5	10
Shale tile	6 hrs.	6 hrs.	4 hrs. 32 mins.	3 hrs. 47 mins.
Fire clay tile	6	6	4 02	3 17
Shale and fire clay tile		6	4 50	20

Typical illustrations of the effect of the grog on the fire resistance are shown in figures 3 and 4. Figure 3 shows the exposed side of the fire clay panel containing $2^1/_2\%$ of grog after the six-hour fire exposure. This photograph indicates that few fire effects developed during the tests. A close inspection of the wall showed that a number of the fire-side shells were loosened to such an extent that they could be easily pulled away. No cracks were found beyond the center web of the tile. Figure 4 shows the unexposed side of the fire clay panel containing 10 per cent grog which failed under its working load after a fire exposure of 3 hours and 17 minutes.

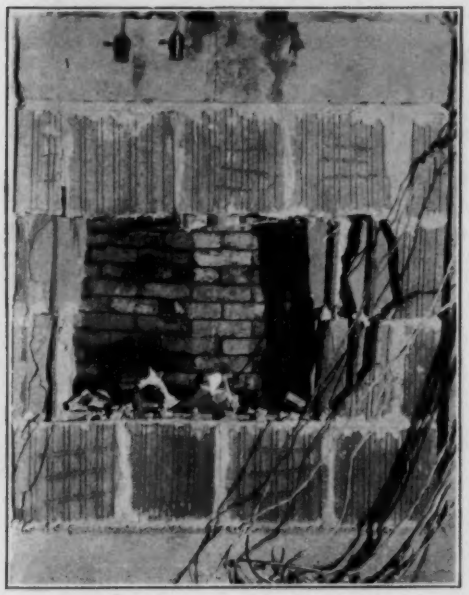

FIG. 4.—Fire clay panel containing 10% of grog, after fire test.

Examinations under the microscope of fractures of tile containing grog disclose very minute cracks, probably from drying and burning shrinkage, radiating from the grog particles into the clay matrix. These fine cracks may be responsible for the early cracking of the tile body.

From the results of these fire tests it can be concluded that the small grog additions which can be conveniently made in manufacturing practice have no effect but that additions of 5% or more will materially decrease the fire resistance of hollow tile.

REQUIREMENTS OF REFRACTORIES FOR ELECTRIC FURNACES[1]

By Clyde E. Williams

ABSTRACT

This article is essentially a survey, giving, however, not generalized statements, but a definite discussion of the refractories problems now existing in the important electric furnace processes. After summarizing some of the general refractory requirements of electric furnace work, the author discusses the specific conditions and refractory requirements in steel, iron, and non-ferrous metal melting, smelting furnaces for producing iron, ferro-alloys and calcium carbide, and in furnaces for melting refractory materials. The article closes with a summary of outstanding present developments.

Varied conditions probably make an ideal, universal refractory almost impossible of attainment. The relatively cheap refractories standardized in fuel-fired furnaces have been very largely used in electric furnaces. There is, however, a growing use for specialized "super-refractories," even at greatly increased cost, that will stand various especially severe conditions in certain kinds of work.

Important recent developments are higher firing temperatures, the use of high aluminous fire clays, and increased experimental work on fused refractories. The commercial production of sufficiently high firing temperatures, and the development of satisfactory bonds for special refractories are at present perplexing problems.

Introduction

One of the most important problems before the electric furnace industry is that of obtaining suitable refractories, the lack of which perhaps more than any other factor has held back a more rapid development of this industry. Naturally, the requirements for the various types of electric furnaces are different. An ideal refractory would be one of universal application, but, unfortunately, such a refractory has not yet been developed and probably never will be. The present tendency toward better heat insulation for the purpose of conserving as much energy as possible increases the demands made upon the refractory. Fire clay, silica, and magnesite are in most general use for electric furnace work, probably because they are comparatively cheap and were already in wide use in fuel-fired furnaces, and, hence, available for use in the more recent electric-furnace industry. The fact that these relatively cheap refractories are now generally used does not mean that a refractory with a higher first cost would not be accepted by the trade. On account of the high cost of repairing and replacing linings, more expensive refractories could be used if linings of longer life were produced thereby.

General Requirements

It is difficult to list the requirements of refractories for use in so broad a field as that covered by the electric furnace industry. Each furnace and each process had its individual conditions that must be met, but certain general requirements that apply in most cases may be outlined.

[1] Presented before Refractories Division, Pittsburgh meeting, February, 1923.

A high fusing temperature is important. This fusing temperature should be determined under a load greater than that under which the refractory will be used. If the refractory lining is used without insulation, and its heat conductivity is high, that portion of it farthest from the heat will be relatively cool and a greater load will be supported than is indicated by the load test. High heat conductivity is also an advantage in refractories used for the construction of externally-heated muffles and of resistor troughs in resistance furnaces. Expansion or contraction with temperature changes causes spalling if the furnace is subjected to rapid changes in temperature. Constancy of volume is, therefore, an important requisite. Excessive shrinkage may occur in some brick when heated to a temperature higher than that at which they were originally fired, causing them to drop out, or the roof to slump. Refractories containing oxides (as, for example, oxides of calcium, iron, magnesium, silicon, aluminum, etc.) will tend to form fusible compounds with the constituents of the slag, while such refractories as carbon, carbides, nitrides, etc., may at high temperatures be oxidized by some of the oxides contained in the slag. Gases and fumes rising from molten baths have the same chemical action on the refractory with which they come in contact as do similar constituents of the slag. Metals corrode linings largely by their physical abrading action, although they may actually react with the refractory material, as, for example, carbon or silicon carbide may be dissolved by molten steel. High electrical conductivity is undesirable for refractories in most cases, although this property is sometimes used to advantage by those furnaces using a conducting hearth.

Specific Requirements of Types of Furnaces

Rather than attempt to list a number of specific requirements of refractories for different furnaces and processes, examples of the various operations will be given.

Steel Melting.—In the melting or refining of steel in the electric furnace, the temperature of the metal is raised to about 1600°C, a temperature approaching very closely to the softening point of many of the refractories in general use and far above that of some. It is evident that the linings of most furnaces must be heated to a higher temperature than this. There are two general processes used in melting steel, namely, the "acid" and "basic" processes. In the acid process, the side walls and roof are constructed of an acid refractory, such as silica brick; an acid slag is used, and no refining is done. Consequently, the charge is melted rapidly and is not held in the furnace for a long period of time. As a result, overheating of the refractory, fluxing of the side walls by the slag, and corrosion of the roof by volatilized lime are not excessive. In the basic process, a basic lining, such as magnesite, and a roof of silica are ordinarily used.

A slag of high-lime content is placed over the charge, and the molten steel is held for a long period of time in order to permit the refining to take place. As a result, the lining becomes overheated and a large amount of lime is volatilized from the slag. This lime is an active flux for siliceous materials and causes early deterioration of the roof. The lime-slag used usually contains silica which, at the high temperature prevailing, attacks the refractory at the slag line. In either process the close proximity of the electric arc to the side walls will cause super-heating and destruction of the lining near that point. Magnesia is decomposed by carbon at a high temperature and is badly corroded by the arc. Iron oxide, if present in the refractory material used for the bottom, may dissolve in the hot iron and thus introduce oxygen to the metal, increasing the refining difficulties.

For economy of construction and operation, the roof should be as close to the metal as practicable. This would require a refractory of higher softening point under load. A refractory of too high heat conductivity would cause too large energy losses and one whose heat conductivity is low, or one used with insulation, would have to withstand higher temperatures under load. The refractory material for both the walls and the roof should withstand the high temperatures under load, should be inert both toward the acid and basic constituents of the slag or the fumes, and should be unaffected by molten steel. In many instances, it should withstand rapid temperature changes without excessive spalling.

The direct arc type furnace is in widest use in this country for steel melting. In this furnace, heat is transmitted to the charge by an electric arc which passes directly from the electrode to the metal and by reflection from the roof and walls which are heated by the arc. These furnaces are built in large sizes and the refractories, especially those in the roof, are under large mechanical stresses and should withstand more severe load tests than those used in some of the other types. On the other hand, the heat is not concentrated in so small a volume as in the case of the smaller furnaces and there is not the high degree of overheating by the arc. In those furnaces using a conducting hearth, refractories for the bottom should have high electrical conductivity.

The indirect arc furnace is used in steel-melting practice, and there are several different varieties of this type of furnace in use. In the indirect arc furnace an arc is struck between electrodes placed above the charge and the heat is transmitted to the metal by radiation from the arc and reflection from the walls and roof. On the whole, these furnaces are smaller than most of the direct arc furnaces, and, hence, the refractories may receive more local overheating, but, on the other hand, the load impressed is not so high, and, as a result, the refractory would withstand a higher temperature than it would in the larger furnaces.

The induction furnace has not been generally introduced to steel-melting

practice in this country, although many advantages are claimed for it and it is in wide use in Europe. A 2-ton furnace has been in successful operation in Pittsfield, Mass., and two others are said to be in operation in this country. One factor which has kept the induction furnace from developing more rapidly has been the difficulty of obtaining a suitable lining for the hearth. A satisfactory lining for basic operation has been developed for the aforementioned furnace at Pittsfield, with which 604 consecutive heats have been obtained.[1] The induction furnace is essentially a transformer whose secondary coil consists of a ring of the metal which is heated by the electric current induced from the primary winding. The induced current gives rise to circulation of the metal which should keep the temperature of the lining uniform and prevent local overheating. In the induction furnace there are no electrodes, the heat being generated in the metal. Hence, the slag is at a lower temperature than in similar operations in other types of furnaces and there should be less corrosion of the roof by ascending vapors.

The resistance furnace has not been introduced into steel-melting practice, although one instance of its use for melting steel scrap in an experimental run has been recorded.[2] In the operation of this furnace most of the heat is transmitted to the metal by reflection from the roof, while some comes from the troughs containing the resistor material. Undoubtedly, the refractories in this furnace used for steel melting would be subjected to excessive temperatures. If this furnace is used commercially for melting steel, it would be desirable, in order to prevent excessive losses of heat, to find a refractory for the roof that will withstand temperatures considerably greater than do those which are now in common use.

Iron Melting.—The conditions in the operation of iron-melting furnaces are similar in almost every respect to those in steel melting, except that the metal is held molten at a lower temperature (not over 1400°C), and usually less refining is done. In the duplex process, hot iron comes from the cupola and is finished in the electric furnace. Thus, the temperature changes are not great and spalling troubles are lessened. In melting cold scrap or pig iron, however, rapid temperature changes are experienced. In general, the statements made above in regard to steel melting apply here except that none of the conditions mentioned are quite so severe in the melting of iron. Intermittent operation with the subsequent cooling of the furnace subjects the lining to severe spalling action and, inasmuch as it is desirable in foundries to operate intermittently, it is highly important that the refractory be relatively free from volume changes when passing through relatively rapid temperature changes between the limits of about 1500°C and normal temperatures.

[1] H. A. Winne, *The Foundry*, Jan. 1, **1922.**

[2] "Melting Steel in Non-ferrous Electric Furnace," *Iron Age*, **108,** 472 (1921).

Non-ferrous Metal Melting.—In most non-ferrous melting practice the temperatures used are relatively low. In many cases the highest temperature to which the metal is heated is about 1100°C, the temperature of the lining in some furnaces being raised considerably higher than this. Since these furnaces are for the most part quite small, running usually from one-quarter ton to two tons in capacity, the heat is more concentrated in the crucible and the refractory lining is subjected to more severe heating than would be the case in larger furnaces. The load under which these refractories are held would be relatively small and the requirements in this direction would therefore be less. The intermittent methods of operation with the resulting temperature changes subject the refractory to spalling, although this is avoided in some furnaces by keeping a small load on during periods of rest in order to avoid the necessity of heating up before the next melt. The absence of slags removes one important requirement, but the corrosive action of some of the fumes, particularly in the case of lead, adds one in its place. The washing of the metal over the hot surface of the lining in the rocking or rotating indirect-arc furnace causes a more even distribution of heat than is found in the stationary types. The high concentration of heat at the roof of the common resistance furnaces makes particularly heavy demands upon the roof. An important problem in the non-ferrous alloy field is the development of a refractory that can be used in melting alloys of high lead content. This is of particular significance in the case of the vertical ring induction furnace. The high-frequency induction furnace makes possible the easy attainment of temperatures higher than those usually employed, and it is highly desirable that a satisfactory refractory be developed for this use.

Smelting Furnaces.—If the electric smelting furnace is designed properly, there is less failure of the lining than in furnaces used in the various melting practices referred to above. Of course, there are exceptions to this statement, because in some smelting operations, products are formed which attack almost any lining that can be used and in such cases the success of the process depends upon the development of a suitable refractory. Most smelting furnaces are of the open-top pit type, the electrodes being inserted into the charge and the heat generated by the resistance of the charge to the flow of the electric current and by small submerged arcs playing between the particles of the charge. The most important refractory trouble is due to corrosion of the lining by the chemical action of slags, metals, or vapors.

In the production of ferromanganese, a refractory is required that will withstand the action of a basic slag carrying a high percentage of lime and manganese, and, in addition, some silica and alumina. This slag attacks both basic and acid refractories. Such refractories as carbon or silicon carbide should withstand the action of the slag better than any of the

others, but they reduce manganese and iron oxides at the high temperature prevailing and are also soluble in the hot metal produced. However, both of these refractories have given satisfaction in practice. Magnesia withstands the action of the slag very well and also is not attacked by carbon at the temperatures used. It may, however, be attacked by the arc if an electrode is pushed near the wall and excessive arcing occurs. Magnesite grout rammed with pitch has given satisfaction in a number of instances. Fire clay and the acid refractories are more readily attacked by the basic constituents of the charge but have proved very satisfactory when used in thin walls cooled by air or water, which arrangement cools the charge and causes it to solidify on the lining and thereby form a new lining.

No serious refractory difficulties are experienced in the operation of ferrosilicon furnaces. The crucible of these furnaces is usually lined with rammed carbon or carbon blocks and the wall is made up of silica or fire clay brick. The charge consists of quartzite of high silica content, rich iron ore, or scrap iron, and coke or coal. The production of slag is avoided as far as possible, the attempt being made to reduce all of the constituents of the charge to metal. The fusing temperature of the charge is so high that the walls of the furnace are soon covered with a refractory layer of partly fused silica which protects the lining from further action. Carbon is a satisfactory material for the crucible lining because it is not dissolved in ferrosilicon and a sufficient excess of carbon is used in the charge to protect the lining from oxidation.

Ferrochromium, ferrovanadium, ferrotungsten, ferromolybdenum, and some of the other less common alloys ordinarily use a carbon-lined furnace either made up from rammed carbon and pitch or carbon blocks. In some cases, magnesia is used. Carbon should be satisfactory in most instances, but cannot be used in the production of low-carbon alloys, such as, for example, low-carbon ferrochrome, in which carbon is quite soluble. In such cases a lining made up of the ore being treated proves desirable as, in ferrochrome practice, chromite has proved satisfactory; or a basic lining, such as magnesia, may be used to advantage. One of the disadvantages of carbon or silicon carbide in these small alloy furnaces is that both carbon and silicon carbide conduct the electric current and unless the furnace is designed to avoid it a large portion of the current will flow through the walls and not into the charge, thereby producing a cold bottom and other irregularities in furnace operation. Such materials as carbon and silicon carbide are also good conductors of heat, and, in order to avoid too great heat losses, should be well insulated.

To solve all of the refractory problems connected with ferro-alloy smelting, a refractory should possess the following properties: Relative inertness to the action of the slags used; freedom from oxidation by iron oxide or

the other metallic oxides present; insolubility in molten ferro-alloys; low heat conductivity, low electrical conductivity, and freedom from spalling when used in furnaces operating intermittently. The principle whereby thin walls are cooled to permit the formation of a new lining consisting essentially of the charged material may be used advantageously. This practice, however, increases the heat losses and prohibits the use of a single furnace for the preparation of a variety of alloys consecutively.

The furnaces for melting alumina, magnesia, spinel, sillimanite, etc., take advantage of the principle mentioned above, namely, the cooling of the walls and the freezing of a part of the charge on them. In this case, however, a steel shell alone is used and is cooled either by air or water. A suitable lining is readily formed by the solidification of the material being melted. This practice entails a large loss of energy by the conduction of heat through the walls but is probably the best practice when it is considered that the temperatures used (from 1800°C to 2000°C) are greater than any that the present-developed refractories are able to withstand. Furthermore, it would be quite impossible to develop a lining that would not react with molten oxides at these high temperatures.

In operation of furnaces used for the production of calcium carbide a temperature above 1800°C is required. Lime and carbon are used in the charge and it is to be expected that either a carbon or a basic lining would be necessary. However, fire clay brick can be used because the fusing point of the calcium carbide is so high that some of it solidifies next to the relatively cool lining and protects it from the action of the heat and charge.

No furnaces are in operation in this country for the electric smelting of iron ores, although there are a number in Europe and two have recently been installed in Brazil. Two kinds of furnaces are used, the shaft type and the open-top or pit type. The shaft furnace consists of a crucible or hearth, and, resting upon this, a shaft. The hearth is usually lined with dead-burned magnesia rammed with pitch. It is covered with an arched roof through which electrodes extend into the crucible. The roof consists of fire brick cooled by the circulation of gases which pass through tuyeres into the hearth just under the arch, thence up through the stack and after being cooled, return to the tuyères. The roof is the weakest point in the construction. It is probable that this furnace will be replaced in future developments by the simpler pit furnace. In the pit furnace the operations are similar to those of ferromanganese smelting and the refractory requirements are alike in both cases.

Present Developments

Important recent developments have been a wider use of high aluminous fire clays and higher temperatures of firing. The addition of aluminum

oxide to fire clay in various amounts up to and even greater than the content of sillimanite ($Al_2O_3 . SiO_2$) has produced refractories that have been very satisfactory in many instances. The presence of the excess aluminum oxide increases the fusion temperature and in many cases reduces the corrosion of both slags and gases. These mixtures have given satisfactory results in the roofs of a number of different types of furnaces, especially those of short span where the pressure has not been great. Bauxite brick are giving more satisfaction now that they are being burned at higher temperatures and all of the shrinkage has been taken care of before they are put into use.

The so-called "super-refractories" are coming into wider use and more fundamental information is being obtained regarding their properties. Silicon carbide is now a rather common article and its properties are well known and have been described in the technical literature. Fused magnesia is coming to the fore but satisfactory methods of bonding it are not generally known. Moreover, it is not definitely known whether fused magnesia will be more satisfactory for general use than properly made "dead-burned" magnesia. A well-conducted comparison of these two products is needed. Fused alumina, sillimanite, spinel ($MgOAl_2O_3$), zircon, and many others are being experimented with and used in commercial operations to some extent. Each one has given encouraging results and, although the pure synthetic compounds have shown remarkable properties, complete knowledge of the fundamental refractory properties of these various materials, as prepared commercially, is not yet available. The commercial product will contain impurities, and it seems very important that work of a fundamental nature be done on the commercial grades of these products. In practically all of the super-refractories now under consideration, the inability to develop a suitable bond and the difficulty of firing the brick to high enough temperature have been important factors in holding back widespread application of these materials.

Progress is being made in the solution of this important problem of developing better refractories for electric furnaces, but it will proceed more rapidly as the metallurgists and ceramists coöperate more closely in working out this mutual problem.

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A RAPID METHOD FOR PREPARING A SILICATE ROCK FLUX FOR DEHYDRATION

By George W. Burke

ABSTRACT

When time is an important factor in the analysis of silicate rock or clay the following method of treating the flux will be found advantageous. The molten flux is poured into the bore of a steel cylinder that is resting on an iron plate. A tightly fitting plunger is inserted into the bore and rapped smartly with a hammer. The broken flux is swept into a dish where it is dissolved in acid.

When samples of clay, sand and silicate rocks containing from 50 to 75% of silica are fused with normal sodium carbonate a relatively large amount of flux is formed that is usually difficult to remove from the crucible. Some allow the melt to solidify in the bottom of the crucible and then remove by treatment with acid. Others cause the melt to solidify

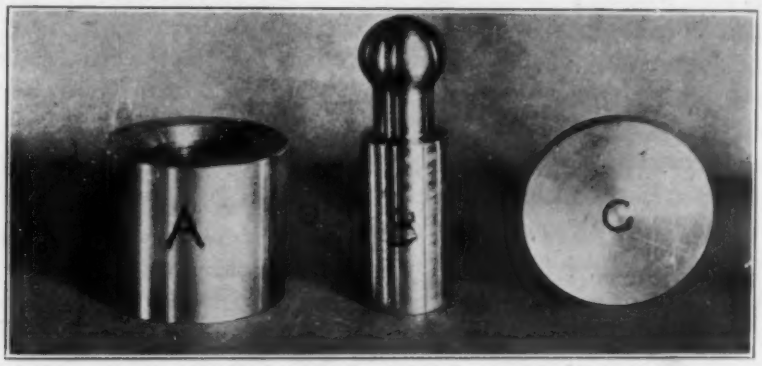

Fig. 1.—Apparatus for disintegrating the flux button.

on the sides and bottom of the crucible by giving it a gyratory motion while the flux is still hot. In this case the flux must be removed by acid treatment. Another method practiced by some is to pour the molten flux into a platinum dish that is riding on the surface of cold water contained in a beaker.

In the above cases several hours are generally required for the melt to become sufficiently disintegrated for dehydration. Again, the crucibles are held up for further use until entirely freed from the flux.

A rapid method for working up a flux high in silica is accomplished by making use of a simple apparatus. (See Fig. 1) described as follows: The apparatus consists of three pieces, a cylinder *A*, plunger *B*, and flat plate *C*, all of which are made of cold rolled steel. The cylinder is about 2 inches in diameter, $1^3/_4$ inches high and has a 1-inch bore that is bevelled at the top. The bottom is machined perfectly flat and smooth. The plunger fits the bore of the cylinder snugly and is provided with a

groove on its surface to avoid compression in the cylinder. The plate is about $^1/_4$ inch thick and is slightly larger in diameter than the cylinder. Both faces of the plate are machined perfectly smooth and flat.

For use, the bottom plate is placed in the center of a piece of glazed paper and the cylinder is placed on the plate. When the fusion is complete the crucible is seized by its rim with the tongs and the molten flux is quickly poured into the bore of the cylinder. The melt quickly cools and forms a button that does not stick to the steel. If one so desires the melt can be poured out into a platinum disk that is floating on cold water. When sufficiently cool the button can be transferred to the bore of the cylinder. After the button has cooled the plunger is placed in the bore of the cylinder, the latter is held tightly in place on the plate, and the plunger is given a few smart raps with a hammer. Such treatment breaks the button into fine pieces. The disintegrated button is brushed on to the glazed paper and is then transferred to the dish in which the dehydration is to be made where it is easily dissolved by treatment with sufficient quantity of 1:1 hydrochloric acid. The thin film of flux remaining in the crucible can be quickly removed by immersing the latter into the dish containing the dissolving flux.[1]

By the method described above the crucible in which the fusion was made can be liberated for further use in a very few minutes, and the flux is ready for dehydration in about one half hour.

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[1] If such an apparatus as described above is not easily available a diamond motor such as is used by mineralogists can probably be satisfactorily used.

CLAY AS A MEDIUM THROUGH WHICH EDUCATIONAL IDEALS MAY BE EFFECTIVELY PRESENTED[1]

By James C. Boudreau

Introduction

Education is the threefold growth of man, physical, mental and cultural. Pedagogy is the science of fostering this growth. If, as an educator, one appreciates that he is not teaching art, handwork, mathematics or English, but rather is teaching children through the medium of these subjects, the objectives will be expressed and the results measured in terms of child growth.

Clay, because of its individual properties, offers many unique possibilities of presenting educational ideals that cannot as effectively be realized through any other medium. Two facts are quite evident in the program as applied to education in public schools built around clay; first, that the objectives are variable in different grades; second, that emphasis is primarily upon education in art appreciation.

Educational Possibilities

Two years ago at Columbus, on invitation from the American Ceramic Society that I be present in the interest of education at the formation of the Art Division, I gave a short talk presenting the educational possibilities open to such an organization. I found I was a little out of step with the rest of the group, and my presentation was not very favorably received, not because it was not worth while, I think, but because the people in the section at the time were very busy thinking of and discussing other phases of the activities of the Division. At that time the thing that was all engrossing was the possibility of trying to interest the manufacturers in the need of employing artists to increase the value and the beauty of their ware. I, striking my discord rather emphatically, brought out the point that I thought that that was not the only thing we should do in an Art Section. I maintained that we should have an organized program whereby we would develop the art appreciation of our buying public, and that only by giving the right work in our art courses in the public schools could we raise the standards of the buying public; for the children who today were in school, tomorrow would be the purchasers of our different manufactured products. The meeting two years ago was centered on the fact that ceramic artists should be employed. We gave no thought at that time to the educational value of ceramic work. Since then I find that some of those people have had a chance to stop and think, with the result that they realize that perhaps, after all, it is well for the American Ceramic Society to be interested in the way art appreciation is developed in the public school program.

[1] Presented before the Art Division, Pittsburgh Meeting, February, 1923.

Cultivating Art Appreciation

As you know, the average manufacturer, irrespective of the field he is in, cares little about art from the standpoint of art appreciation. That is not his business. What he wants to do is to develop a product that will sell. Now, it is our aim to have a market of tomorrow that will demand better ceramic products. Therefore, we must project an educational program of art appreciation having ceramic content.

A parallel change for the better, as the result of art education in the public schools, is evident in the difference in textile offerings of today as contrasted with those of only a few years ago. Ten or twelve years ago you could visit any worth while department store, and in the rug department be confronted with quite a preponderance of those hideous rugs with realistic dogs or roses or castles on them. We all recall them. About a month ago I was at one of our department stores, and looking around saw none of those grotesque floor coverings. Incidentally, I put this question to the head salesman, "What has become of all those picture rugs you used to sell the buying public?" to which he replied, "Well, the demand has dwindled to the point where we finally have ceased to stock them; the public will not buy them; they want something better in design." It is no mere accident that this evidence, the fact that American standards in textile desires have been raised, coincides with the national acceptance of design as a subject in the public school program.

Now, if we have a definite art educational program in relation to the ceramic field, there is no doubt but that the public, which will buy tomorrow, is going to demand better things, and naturally if they cannot get them in this country, they will get them from other countries. Our function, therefore, is to develop the appreciation of the coming buying public, and then there is not a doubt in the world but that our manufacturers will meet the demand of their public, thus calling into service our artist potters. It is their duty to have something that will sell to the public. I say, they do not care; it is not within their function to care whether it is beautiful or hideous, just as long as it sells. Of course, we of artistic bent are intensely keen that it be beautiful as well as salable. To realize our desire, our educational program and our art pottery program should go hand in hand. We have to have many appreciators where we have only one creator.

In the entire art program in the public schools in Pittsburgh, our effort is primarily to develop art appreciation. I shall not go into detail in relation to any activities other than clay. As was stated in the introduction, education means the threefold development of man, that is, the physical, mental and cultural development. We feel in our art program, as a whole, that our main emphasis should be on the cultural development, for there

we have an opportunity that no other subject, not even music or literature, can touch as effectively as we can.

Clay Modeling as a Means of Self-Expression

While that is our main emphasis in relation to studying clay in the Pittsburgh program, we find we can foster through clay other developments, certain mental and physical growths that cannot as successfully be reached by other means. You will notice, as I unfold the program of the public school, from the first grade through the high school, that there are varying objectives, and also that the objectives are stated in terms of growth of the child and not in terms of objective results. In like manner we measure our results in the attained growth, and not in the objects that are created by the child.

In the first four grades we use clay in the Pittsburgh schools chiefly as a means of self-expression. It goes hand-in-hand with writing, drawing and speech. We find that the child can talk through the language of clay with a facility that is not equalled in other mediums. A child is often handicapped in his oral expression when he tries to talk about something, but if he is allowed to express himself in clay, he can talk very effectively. The ready responsiveness of clay wins the love of the child and immediately unlocks those creative desires so precious to mankind. He can express his ideas much more clearly in a concrete than an abstract manner. So in the first four grades we use clay primarily with that objective in mind—to develop this additional facile means of self-expression. But along with it, we get a certain physical development, particularly a better control of the finer muscles of the hand and forearm. This work improves, by repeated experiences, the coördination of the hand and mind. No other medium presents an equal opportunity to develop two-handedness. While in drawing, the child's self-expression is in terms of two dimensions, in clay work, he has a chance to think and express in three dimensions. In these several objectives, we are using clay as a pedagogical asset, because of its own individual characteristics, an approach quite apt to be foreign to you and me as ceramists.

In the fifth grade, we change our objectives. Here we start to study the use of clay from the standpoint of the sculptor and of the architect. We allow the child to do a little modeling and some architectural detail, with the objective absolutely upon art appreciation. It is the first manipulative introduction the child has to a knowledge of the sculptor and the architect and their art creations. We are not trying to make sculptors or architects in this work in the fifth grade, but rather to develop an appreciation through the very valuable concrete means of a definite contact with the materials that these two great art contributors use.

In the sixth grade, we place our emphasis upon an appreciation of pottery

together with an industrial insight into ceramic production. During this year the child does a bit of building—not, as I say, to make potters, but to get an intimate appreciation of the potter and his product. We stress the beauty of line and form rather than technique. Also in this grade we do some casting.

Subjective Results Obtained

We are not working for products in the sense of the objective results, but are teaching art appreciation. It is an accepted fact that one of the most forceful ways to learn is to do. We can read about paintings, but we shall never appreciate the artist's problems as thoroughly as when we are allowed to take a brush and paints and try to do a little painting—we soon realize the painter's possibilities and limitations.

Where convenient, the children, as a community group, develop two or three molds from which every child pours at least one piece. Our objective here is an introduction to one phase of the ceramic industry. By teaching the process of casting, we acquaint the child with one of the big industrial possibilities of clay; since we all know we would not get very far in our ceramic industry if we had to build all our pottery by hand, as did the first potters, I feel the child has a right not only to know how primitives built, but also how we produce our pottery today. Through casting we have an excellent opportunity to realize our second sixth grade objective, namely, a knowledge of ceramic industrial production as related to pottery.

In this city we are gradually changing to what is known, in educational circles, as the 6–3–3 plan, six grades for the elementary school, three for the junior high school, and three for the senior high school. As soon as we get organized definitely in the junior high school, it is my hope to have clay in each grade. At present our emphasis in relation to clay in the seventh and eighth grades is the further development of the appreciation of sculpture, architecture, and pottery by means of pictures, lantern slides and exhibits. During the eighth year all the public school students visit the Department of Fine Arts, Carnegie Museum, three times as part of their regular program. Three lectures, one on each of the fine arts, painting, sculpture and architecture, are given using the very excellent material at the Museum for illustrations.

The program at present, then, provides that every child in the Pittsburgh schools has an actual contact with clay in each of his first six years in school. As soon as the junior high school plan is in complete operation, every child in the seventh and eighth grades will enrich his art appreciation through manipulating clay. From the end of the eighth grade on, as at present, the art work will be elective, starting with the ninth grade or with what at present constitutes the regular four year senior high school.

High School Program of Study

It is well to acquaint you with our objectives in Pittsburgh relative to that part of our high school art program that involves the use of clay. Perhaps the best way to present them will be to first state our negative objective. We are not teaching pottery in the high schools of Pittsburgh with the idea of giving all a vocational training. It is not primarily a vocational course. We do not claim, when a student leaves the senior high school, that he is capable of taking a position as a tradesman in any pottery plant, any more than we maintain that he can go forth as a trained art potter ready to open up a studio of his own for creative work. Instead, we carry very much the same thought through the high school program that we have in the grades, namely, a cultural growth through the development of art appreciation. This major objective, however, is supplemented with another which has vocational significance. We watch for the students of special interests and aptitudes. They are given specific information regarding the opportunities of the ceramic field. As a result we send to craft and ceramic schools some of our high school graduates each year.

We are able to present a very rich experience in the high school because of the fact that the students who take the pottery course spend much time with us during a school year. When one elects pottery, he has one credit hour period every day in the school week, so that in a year's time he has taken pottery for forty weeks, or two hundred credit hours. While our course is scheduled as pottery, each student does some modeling also.

The following is the program by which we claim and feel confident that our objectives are realized. We have a general approach for all our students and a specific approach. In the general approach every student who elects the pottery course has some contact with art appreciation as revealed in painting, sculpture, and architecture. This phase of the program includes at least six sessions during the year devoted to the Fine Arts and may be developed by any of the following means: lectures, reports, loan exhibits, discussions, museum trips or other excursions. In our specific art appreciation program, we emphasize the crafts. Every one studying pottery in the high school has an opportunity to become acquainted with the several art crafts, including bookbinding, jewelry, metal work, such as copper and brass, iron work, block printing, and textile dyeing. This craft appreciation is realized by the several above-named means of development.

Naturally our very definite craft appreciation in the pottery department is centered about pottery and modeling, and we get our concrete approach through the one medium of clay. One may elect metal work, bookbinding or block printing instead of pottery as their craft subject,

yet the course is fundamentally the same; the craft appreciation is the same, but they have a chance in the studio or laboratory to apply it to some other specific medium. We could not possibly have a child work in all the various crafts in a year's time. All are given the general approach to the several crafts and then they apply this general information to any one craft they may have elected.

We also have a color and design approach, both from the standpoint of theory and application. In our theory we study the principles of color and of design. In our application we note the evidence of these principles in the various crafts and then apply them specifically to the pottery. We present an enriched insight into chemistry as the result of our glazing and firing activities. From raw materials are compiled our entire glaze palette, and there are always a few test pieces in every fire. The interest of the students in this part of the program, as with us, is very keen.

We have in operation a policy in connection with our high school pottery program, relative to pupil eligibility. We aim to reach as many people in the high school as possible. This policy naturally develops as a result of our objectives. After all, the public school is not an art school. It is a general educational institution, and I believe firmly that the main function of art education in the high schools, as in the grades, is to develop that phase of educational growth, which cannot be reached successfully by other subjects. Therefore, in putting our emphasis on culture, we should try to reach as many students as possible in high school.

We much prefer to have two hundred students take pottery for a year than to enroll one hundred for two years. We have a few students with us beyond the first two semesters, but we only permit these few to come in for advance work when space remains after satisfying new students' requests for admission.

Instituting any school with a major vocational intent must employ an opposite policy. It may be that some time in the future, local industrial development will justify the instituting of vocational courses in pottery in addition to our present program. If it does, we shall develop a new program of different objectives and policies to meet the new need.

From the outline of our high school program, you can see that we do not employ the entire time of our students in execution, but rather we present the handling of clay as an enriching supplementary and laboratory experimental approach for the purpose of concretely reinforcing the "Art Appreciation" objective. Our thought is to develop an attitude rather than many pieces.

I have stated in detail both the grade and the high school program to show you that our objectives are different from those of either the manufacturer or the creative potter. Yet despite these different approaches to clay that the educator, the manufacturer and the art potter have,

nevertheless, we all have many things in common. We are all going in the same direction, but through different avenues, and I am confident that if we are to arrive, we must know and understand each other thoroughly. Let us all so coördinate in the future that we shall realize to their fullest measure the educational ideals that may be effectively presented through clay as a medium.

Discussion

C. F. BINNS:—I have never heard a better presentation of the ideals and work of a grade and a high school art program than Mr. Boudreau has given, and it appeals to me very strongly indeed. I congratulate him upon it. I would like to see this address distributed far and wide, if it can be done. The schools need it, and if these ideas can be carried out we shall have accomplished a good deal.

CHAIRMAN F. H. RHEAD:—I should like to second Professor Binns' remarks in connection with that paper. Do you know how many years ago it was when we had our first Art Division meeting?

J. C. BOUDREAU:—That was two years ago, in Columbus.

CHAIRMAN RHEAD:—The first Art Division meeting was very cut and dried. We had worked some time on it. Mr. Solon had a paper; Mr. Dressler had a paper on faience; and there were one or two other papers. We read these papers and transacted our business; then this young man stood up and talked along these lines. I am interested in the industrial side. I have gone through the curriculum of the English Art Student but I had never realized his point of view at all. After the meeting was over we discussed these new ideas that were being thrust upon us. We couldn't understand them at all. The idea that anybody should have an education in art appreciation, should be taught something that he was not going to use in later life in a practical way was new to us. The wisdom of teaching art to someone who would not use it seemed dubious. Now we are so enthusiastic about this phase of the possible work of the Art Division that we have divided the activities of the Art Division into the educational side and the industrial work, and Mr. Boudreau is going to direct that educational side of the work.

G. O. TOTTEN, JR.:—I am very much impressed with Mr. Boudreau's paper. I do not know the status of the schools in Washington, D. C., where I live. I have just suggested to Mrs. Totten, who is a sculptor, that we make a survey of the situation in the public schools at Washington.

H. S. KIRK:—I am extremely interested with the educational possibilities of spreading this plan, because I know from the manufacturers' standpoint that they are out to supply the public with what they demand. If you are going to raise your standard product, you will first have to raise the standard of your buying public.

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IMPORTANT COMMUNICATION ON THE RAILWAY SITUATION

Due to the war and the long continued impossibility on the part of the railways to finance the necessary betterments, both our production capacity and consuming demands have now advanced beyond our transportation facilities. The railway managers under the recent improved conditions are making great effort in finance and expansion of facilities to meet our necessities, but full recovery of lost ground must be slow and, if we are to maintain our present rate of productivity and employment, it is vital that there be coöperation with the railway management from both producing and consuming industries to secure the most efficient operation of the railroads.

The railways have asked for this coöperation, and the trades can make a tremendous contribution to the orderly march of our prosperity if they will undertake it seriously and in an organized fashion.

The principal directions in which such coöperation can be extended by the trades are:

1. The advance storage of their winter coal during the light consuming season—that is, from now until September 1, including the early movement of Lake traffic.
2. The loading of all cars to full capacity, their prompt loading and discharge.
3. Reduction of reconsignment shipment and restriction of to-order bills of lading.
4. Demands for no more cars from the railways than can be promptly used.

If we could secure the maximum efficiency in these directions we will have added more effective commodity movement than would be brought about by the addition of approximately 300,000 cars and 3,000 locomotives, and the addition of at least 10 per cent to our track mileage and terminal facilities.

The importance of this lies in more than simply the maintenance of continuity of production and full supply of consumption, because any strangulation in movement of commodities through car shortages affects the profits of every individual manufacturer by interruption in his production, and furthermore, such strangulation affects price levels in the most definite fashion.

The full and smooth movement of all of the productivity of the country would be the greatest contribution that could be made at the present time in checking inflation or increase in price levels.

CERAMIC ABSTRACTS

Compiled by the

AMERICAN CERAMIC SOCIETY

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Abrasives

PATENT

1. Safety-tread tile. M. F. BEECHER. U. S. 1,439,285, Dec. 19. Si carbide granules forming the main portion of the tread surface of tiles are united into an integral porous mass by a porcelanic bond. Cf. *Ceram. Abs.*, **1** [3], 82(1922). (*C. A.*)

Art

2. Uranium protoxide in Czecho-Slovakia. ANON. *Jour. Royal Soc. Arts*, **71**, 258.—Oxide of black blende, or pitch ore, otherwise known as protoxide of uranium is one of the valuable minerals obtained at the State mines of Jachymov in W. Bohemia, according to a rept. by the U. S. Consul at Prague. This mineral is used in the prepn. of uranium colors and radium, owing to the fact that the Czecho-Slovak Govt. has a monopoly of the production of radium and other precious minerals, a special permit is necessary for their purchase. O. P. R. O.

3. Art and its application to the pottery industry. ANON. *Pottery Gaz.*, **48**, 106–8 (1923).—A rev. of an address by Joseph Burton. J. W. H.

4. Ceramics in the field of architecture. ARTHUR BERESFORD PITE. *Pottery Gaz.*, **47**, 736–8(1922).—An address. J. W. H.

5. Lustered pottery: ancient and modern. GORDON M. FORSYTH. *Pottery Gaz.*, **48**, 95–7(1923).—F. classifies lustered pottery into 2 classes, namely true lusters fired in a reducing atmosphere and false lusters fired in ordinary atm. in a muffle furnace. Historic side of luster decorations is given. Process of applying luster and method of firing is outlined. J. W. H.

6. Classifying and measuring color by the Ostwald method. H. T. TENEN. *Am. Dyestuff Rep.*, **12**, 127–32(1923). E. J. C. (*C. A.*)

Cement, Lime and Plaster

7. Waterproofing cement. ANON. *Chem. Age* (London), **8**, 238(1923).—"Kynazite," a prepn. for waterproofing cement and mortar, has been tested at the College of Tech., Manchester, with good results. This substance is used to replace a propn. of the sand used in manuf., and according to the tests proves an effective waterproofer of mortar and cement in all cases, even for water under pressure, the imperviousness being increased by increasing the propn. of the product. The strength of the materials as detd. by compression tests was found to be slightly greater than ordinary cement and mortar. Concrete made with kynazite replacing the whole of the sand content was found to be highly water resisting, but in this case the strength was only about 50%

of that of plain concrete. It is manufd. by Kynaz Products Co., Ceinws, Montgomeryshire, Eng. O. P. R. O.

8. German research institute for slag-cement. ANON. *Jour. Soc. Chem. Indus.*, **42**, 306.—The Ger. slag-cement indus. has now gained a position of equal importance with the Port. cement indus. and a new Research Institute has been formed and opened at Düsseldorf. O. P. R. O.

9. The production of caustic calcined magnesite in the Scott furnace. W. C. RIDDELL AND C. N. SCHUETTE. *Eng. Mining J.*, **114**, 981–4(1922).—The Scott fur. (commonly used to treat fine mercury ores) is described. Such fur. has been successfully used since 1920. Producing caustic magnesia for use in Sorel cement. Figures on cost and opern. given. Also data on rate of decompn. of different magnesites. S. L. G.

10. Setting and velocity of solution of burnt gypsum. P. P. BUDNIKOV AND JA. K. SYRKIN. *Bull. Inst. Polyt. Ivanovo-Voznesensk.*, **6**, 235–47(1922).—The authors have investigated the velocities of dissolution of gypsum after the latter had been heated at various temps., the concns. being detd. at different stages of the dissolution by means of cond. measurements. For the samples which have been heated at 115° and 125°, the cond. and hence the soly. increases rapidly to a point corresponding with a soln. considerably supersatd. with respect to $CaSO_4.H_2O$, and afterwards diminishes, at first rapidly and then slowly, but still indicates a certain degree of supersatn. after 24 hrs. Supersatd. solns. are obtained also with gypsum heated at 400°, but not when a temp. of 500° is reached. In so far as the setting of gypsum is conditioned by crystn. from supersatd. solns., the temp. at which "dead-burnt" gypsum is formed may therefore be assumed to be about 450°. Burnt gypsum may be regarded as consisting of two components, one sol., which dissolves readily, and the other relatively insol. The soly. of samples which have been burnt at temps. between 500° and 800° is rapid at first, this being explained by the presence of appreciable proportions of the sol. modification in dead-burnt gypsum. The time occupied by dissolution does not furnish an exhaustive explanation of the disappearance of the ability of gypsum to set, and the authors suggest that the presence of the insol. component in the interstices of the crystals prevents the latter from growing. J. C. S. (*C. A.*)

PATENTS

11. Cement mixture. F. FERRARI. U. S. 1,444,309, Feb. 6. A cement mixt. (adapted for withstanding sea water or water containing sulfates) is prepd. by grinding pozzuolanic substances and a special cement contg. Fe_2O_3 and Al_2O_3 free of aluminates and ferrites of Ca, proportioned according to the amts. of available CaO and sand in practical use. (*C. A.*)

12. Elastic cement. W. T. GODDARD. Can. 227,950, Jan. 16, 1923. A cement contains a non-friable aggregate, part of which is initially coated with rubber. Cf. *Ceram. Abs.*, **1** [7], 193(1922). (*C. A.*)

13. Elastic cement. RISSYO TAKAHASHI. Japan. 40,020, Sept. 10, 1921. Thirty parts of soln. of $Al_2(SO_4)_3$ or $BaCl_2$ of 12°Bé. is gradually added to a mixt. of $BaSO_4$ 100 and Turkey red oil 30 and thoroughly mixed together; the insol. elastic substance sepd. from them is completely washed with H_2O and dried *in vacuo*. It is then used for replenishment or manuf. of plastic materials. (*C. A.*)

14. Waterproof tile. MANZO SUGIZAKI. Japan. 40,080, Sept. 28, 1921. Tile prepd. from mortar or cement is heated to about 120°, painted with Japanese lac and then covered with Cu powder. It is once more heated at about 120°. It is resistant to heat and H_2O. (*C. A.*)

15. Continuous updraft vertical shaft lime kiln. V. ARNOLD. U. S. 1,439,597, Dec. 19. (*C. A.*)

16. Magnesia plaster. R. YAMAMOTO. U. S. 1,436,747, Nov. 28. Asbestos or other fibrous material 10, is mixed with MgO 40, pigment 5, powd. peanut shells 5 and a concd. soln. of $MgCl_2$ 44°Bé. dissolved in dil. $Pb(OAc)_2$ soln. 2 parts, to form a plaster which is rendered relatively non-hygroscopic. (*C. A.*)

17. Bricks. C. L. NORTH. U. S. 1,440,234, Dec. 26. Bricks are molded from a mixt. of ground clinker and ash from a coal furnace, lime and H_2O, and are cured with steam under pressure. (*C. A.*)

18. Building block composition. C. A. FOX. U. S. 1,442,764, Jan. 16. A heated mixt. of earthy and oleaginous materials such as earth and asphalt is extruded from a die press and cut into building blocks. (*C. A.*)

19. Floor covering material. W. E. SUMNER. U. S. 1,442,012, Jan. 9. A floor covering material is formed of a waterproofed flexible substance, *e. g.*, felt impregnated with asphalt, with an underlying layer of a mixt. of montan wax, rosin, paraffin and pigment. (*C. A.*)

20. Plaster wall board. J. W. EMERSON. U. S. 1,439,954, Dec. 26. A plaster board is formed largely of plaster of Paris reinforced near its surface with wire cloth or similar material and waterproofed by a gypsum and stearate mixt. (*C. A.*)

21. Strengthening composition for cement mixtures. A. T. MALMED. U. S. 1,436,276, Nov. 21. A mixt. of diatomaceous earth and $CaCl_2$ or similar materials is used for strengthening port. cement concretes and mortars. (*C. A.*)

Enamel

22. Origin of chamotte. ANON. *Brit. Clayworker*, **31**, 371.—There have been many discussions as to the nature of "chamotte" and the origin of this term, and it was for long thought to be derived from "chamois," the cream color of lightly burned firebricks having some resemblance to chamois leather. More recent researches in Germany seem to show a much earlier origin, and suggest that the word was originally "Schlammotte" meaning burned mud. One of the earliest uses of the work (then spelled "Chamotte") is in a document in connection with the Brueckeberger Porcelain Works, in 1793; in this document it relates, as now, to broken saggers used as grog. (*Tonindustrie Zeitung.*) O. P. R. O.

23. Cleaning enamel. ANON. *Oil & Color Trade Jour.*, **63**, 308(1923).—Paste for cleaning metal, horn, enamel, etc. (German pat. 337,066, C. A. R. SAMSIOE, Stockholm.) This paste consists of a mixture of bicarbonate of soda and glycerine, with which may be incorporated coloring, flavoring, and perfuming agents. Being sol. in water, the paste can be readily washed off after use. O. P. R. O.

PATENT

24. Enamel-coated writing tablets. R. ZULAUF. U. S. 1,438,154, Dec. 5. A first enamel coating of ordinary compn. is applied to sheet Fe and "stoved" and a finishing enamel is then "stoved" upon the first coat. The finishing coat is prepd. by grinding a fused enameling mixt. of ordinary compn. with a considerably larger addn. of clay than usually employed. This second coat gives a dull or mat finish. (*C. A.*)

Glass

25. Simpson continuous leer conveyor. ANON. *Glass Worker*, **42** [21], 19(1923).—Parts, construction and opern. of continuous leer developed by Simpson Foundry and Engineering Co., detailed briefly. R. J. M.

26. Decorating table glassware in colors. ANON. *Glass Worker*, **42** [23], 19 (1923).—How ware is decorated at Factory D, U. S. Glass Co. Color applied by spray or by hand and fired in a decorating leer. R. J. M.

27. Standard milk bottles. ANON. *Glass Worker*, **42** [23], 25(1923).—Laws in various states are not uniform as to size, shape and marking on bottles, hence much unnecessary expense in manuf. 23 sizes of caps are in use to-day. R. J. M.

28. Glass industry (Ceylon). ANON. *Pottery Gaz. & Glass Trade Rev.*, **48,** 419(1923).—A sand, which is of excellent quality and highly suitable for making glass, has been discovered in Ceylon, and a factory for its utilization is now being erected at Henaralgoda, about 20 mi. north of Colombo. M. N. Maru, a Japanese, has left for home to obtain the machines necessary for the factory. Considering the large import trade in glassware, the prospects are good provided coconut shells can be used as fuel, as coal is dear and scarce, and the coconut shells are available in large quantities at cheap prices. O. P. R. O.

29. Non-shattering glass. ANON. *Chem. Trade Jour. and Chem. Eng.*, **71,** 456 (1922).—A newly patented glass that does not shatter consists of alternate plates of thin glass and celluloid, treated with a solution of fusel oil, camphor, and methyl salicylate. The assembled laminae are immersed in the solution at a temperature of 75–95°, and pressure is applied to the whole as the temperature is gradually increased, thus firmly cementing the plates together. O. P. R. O.

30. Glass furnace temperatures. LOESER. *Keram. Rundsch.*, **30,** 48(1922).—The detn. of temp. which was reported was made with materials furnished by a German gold and silver ore establishment, on the m. p. of fusible cones and pure salts. In the flame of a Nehse-Dralle fur. of the basin system, a temp. of from 1600° to 1650° was detd. On the surface of the glass the temp. ran from 1497° to 1526°. In the two flues, one recorded a temp. of 1320°, the other 1385°. O. P. R. O.

31. Mirror glass industry (France). ANON. *Jour. Royal Soc. Arts*, **71,** 258 (1923).—The Fr. Mirror Glass Indus. will have regained its former importance within a year or two, according to competent authorities. A thoroughly modern factory is under construction at Compiégne, near Paris, and reconstruction work at Circy is progressing rapidly. O. P. R. O.

32. Effect of alumina in retarding the devitrification of glass. K. KAMITA. *Pottery Gaz.*, **47,** 1369(1922).—The expts. reported in this paper are confined to window glass. Alumina was added in progressive series from 0.0% to 5.0%. A definite increase in the devitrification temp. was obtained as the percentage of alumina began. A regular curve was obtained indicating that with 5% alumina, incipient devitrification set in above 850°C. The expts. did not include the effect that alumina had upon the upper devitrification temp. J. W. H.

33. The mixing of batch. W. E. S. TURNER, V. DIMBLEBY AND A. W. DICKENSON. *Pottery Gaz.*, **47,** 1033, 1035, 1037(1922).—Authors discuss mixing of glass batch. Attention should be directed to having ingredients introduced at a uniform size, to the d. of the particles and the moisture content must be considered. Machine mixing produces a more homogeneous finished product than is generally obtained by hand mixing. J. W. H.

34. Process of manufacturing optical glass. J. DESENBERG. *Jour. Soc. Chem. Indus.*, **42,** 184A(1923).—A recent Ger. patent. A melt differing in av. compn. is solidified and powdered. Melts similarly treated but differing in compn. both from the previous melt and from that of the prescribed glass are added. Alternatively individual components of the glass may be added. In either manner a mixt. approx. as nearly as possible in average compn. to that of the prescribed glass is produced and melted. Waste glass may be used up in this manner, and a good yield of glass of definite optical properties obtained. O. P. R. O.

35. Improvements in the design of recuperative glass pot furnaces. T. TEISEN. *Pottery Gaz.*, **48,** 89–92(1923).—A description of a recuperative glass pot fur. of the

author's design. One of the advantages of this design was increased security against leakages obtained by the crosswise arrangement of air channels in relation to waste gas channels as well as an interlocking principle on which the tubes are made. J. W. H.

36. Processes and methods of mediaeval glass paintings. J. A. KNOWLES. *Pottery Gaz.*, **47**, 1685–8(1922).—Rev. of an address by J. A. Knowles. J. W. H.

37. Devitrification caused upon the surface of sheet glass by heat. Y. AMENOMIYA. *Pottery Gaz.*, **47**, 1369(1922).—Results of expts. with sheet glass show that devitrification takes place more and more rapidly as the temp. is increased within the zone of 700° to 800°C and that this particular temp. range constitutes the danger zone in the drawing of sheet glass cylinders. Cf. *Ceram. Abs.*, **1** [11], 290(1922). J. W. H.

38. The production of colorless glass in tank furnaces. W. E. S. TURNER AND A. COUSEN. *Pottery Gaz.*, **47**, 568–70(1922); **48**, 87, 89(1923).—Results of a study of effect of selenium in decolorizing a soda lime glass under varying conditions. The batches under consideration are as follows:

Sand	100	100	100	100
Soda Ash	37	36	35	33
Limespar	20	20	20	20
Sodium Selenite	0.0065	0.0065	0.0065	0.0065
Selenium	0.003	0.003	0.003	0.003
Cobalt Oxide	0.0005	0.0005	0.0005	0.0005

All meltings were held at temp. of 1370–1380°C for 3 to $3^1/_2$ hrs. It was found (1) the max. percentage of iron oxide in the glass which it was found possible to decolorize, either with selenium or sodium selenite, was 0.09 with a further allowance of possible 0.01 for commercially produced glass; but the smaller the iron oxide content, below 0.09, the better was the glass in appearance. (2) Presence of saltcake, even in very small amts. in the batch called for an increased amt. of selenium for decolorizing purposes. (3) Saltcake batch appeared to be more corrosive on the fire clay material than the corresponding soda ash batch; hence the amt. of iron oxide content in the glass increased and decolorizing became more difficult. (4) There was evidence of the reaction of selenium with saltcake at high temp. and this tended towards the formation of a colorless compd. in the glass. (5) Sodium selenite was found more effective than selenium, and even $^1/_{32}$ of an ounce was found to be more than sufficient for decolorizing under ordinary conditions. Same melts were performed in lined pots. Lining consisted of china clay (iron content 0.7%) and 5% feldspar. The resulting melts had an iron oxide content no greater than 0.05% in 3 hrs. and 0.09% from 8 to 9 hrs. Arsenious oxide was added in some cases. The results obtained are summarized as (1) it seems evident that arsenious oxide and salt cake both act in same way, *viz.*, to reduce the excess color due to selenium, even when the selenium is present in fairly large amts. (2) This effect, apparent at the end of three hrs. continues for at least $8^1/_2$ hrs. at 1300 to 1400°C. (3) Used alone, selenium or sodium selenite, at any rate in amts. normally employed for decolorizing, would give the yellowish brown color noticeable at 1300°C but more pronou nced at 1400°C; but the presence of arsenious oxide or saltcake alone, or probably even the 2 together, tends to prevent formation of this color. (4) Sodium nitrate, contrary to expectations, increases the color of selenium on melting for 3 hrs. and tends toward production of a pink tint. Longer melting gives an increase of the yellowish brown color, and after $8^1/_2$ hrs. but little difference between the soda ash batch and nitre batch can be observed. It is unnecessary to exclude sodium nitrate from a batch for a selenium decolorized glass. J. W. H.

39. The manufacture of white flint glass in a tank furnace. F. W. ADAMS. *Pottery Gaz.*, **47**, 1031–3(1922).—The large market for white flint glass is that of food con-

tainers. Observations of manuf. of white flint glass in a 110 T. tank capable of 25 T. as a nominal output per day. Suitable tank is essential in production of white flint glass; tank must be sufficiently long and deep for melting and fining to be complete. Ends of tank must be large enough to permit metal to settle and attain uniform viscosity. Attention must be directed to quality of tank blocks—in general the higher the percentage of soda in the batch the higher should be the Al_2O_3 content of the block. MnO_2 and selenium are 2 substances in general use as decolorizers. The merits of these are discussed. Temp. of 1350–1400°C gives good results for white flint mixt. intended for automatic working. A. summarizes as follows: Complete analyses should be made of all batch materials especially the decolorizer. Total iron content in finished glass must be maintained constant; fresh components of metal should be checked regularly by complete analyses; careful weighing and efficient mixing of batch ingredients is essential; melting temp. should be kept constant by use of pyrometers; leer temp. should be correctly ascertained for a given type of glass and maintained constant by a temp. recorder. Advisable to have two recorders in leer to maintain a definite temp. gradient. Articles differing greatly in wt. should not be placed in same leer. When correct amt. of decolorizer has been found for batch with given amt. of iron content in total mix and with due regard to fur. conditions then the remaining variables could be stabilized. For discussion of this paper see *Pottery Gaz.*, **47,** 1208–10(1922). J. W. H.

40. Heat resisting glasses. W. E. S. TURNER. *Engineering,* **115,** 274(1923).—In a recent lecture before the Royal Soc. of Arts, T. dealt with the problem of the need for glasses capable of withstanding sudden changes of temp. without fracture, experienced in many industries, notably those requiring miners' lamp glasses, water gage glasses, etc. He pointed out that expts. had been made chiefly in the direction of treatment of the glass after manuf. in a manner somewhat similar to that now adopted by metallurgists for the heat treatment of steels. Owing to the uncertainty of the effects obtainable, the results had been unsatisfactory. The problem has now been attacked from another direction, investigation showing that the "thermal endurance" of a glass varied inversely as the coeff. of expansion, which in its turn is dependent upon the chem. coinpn. Further researches showed that the use of B_2O_3 and SiO_2 lowered the coeff. of expansion, and in "Pyrex" 11.90% B_2O_3 and 80.62% SiO_2 are used, which give a coeff. of expansion of 37.2×10^{-7}, whereas an ordinary silica-lime glass is about 100×10^{-7}. A drawback, however, is the difficulty of manuf. due to the high melting temp. necessary and the very short range of plasticity; this has led to the investigation as to the possibility of using the oxides of zirconium, thorium and titanium. Up to the present results show that although glasses produced possess greater mech. strength, at the same time they also introduce additional disadvantages. A discussion followed in which the suggestion was made that the introduction of TiO_2 in quantities up to 5% increases the workability in the blow-lamp flame and also that the use of the oxide of thorium increases the range of plasticity. Pure fused silica has advantages in that it has a coeff. of expansion only one seventh of "Pyrex." O. P. R. O.

41. A glass-metal joint. M. L. DUNDON. *J. Am. Chem. Soc.*, **45,** 716–7(1923).—A successful method of joining soft glass and Cu and Cu-plated steel tubing is described. E. J. C. (*C. A.*)

42. Anomalies in the expansion of glasses. PIERRE LAFON. *Compt. rend.*, **175,** 955–8(1922).—The curves showing the expansion of glass may be divided into 4 parts: (1) a linear part giving the ordinary coeff. of expansion; (2) a part in which irregular effects occur owing to annealing; (3) a reversible change of vol.; (4) a part in which the glass becomes soft and finally molten. It is claimed that the reversible change (3) is due to an allotropic change in the amorphous silica similar to that which takes place in melted S. E. D. W. (*C. A.*)

43. The problem of carboy closure. ANON. *Chem. Met. Eng.*, **27**, 1267–8(1922).—Carboys with chipped or cracked necks may be reclaimed by grinding the necks sufficiently to make the surface smooth. The app. is illus. and its operation explained. The smooth surface means a saving of plaster of Paris; it is cleaner; better closure is obtained; and disputes between buyer and seller are eliminated. The cost of reclamation is 10 c. per carboy. W. H. B. (*C. A.*)

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44. Glass composition. W. C. TAYLOR. Can. 227,457, Dec. 26, 1922. A glass contains over 70% SiO_2, over 2% B_2O_3 and a halogen compd. Cf. *Ceram. Abs.*, **2** [3], 64(1923). (*C. A.*)

45. Furnace for molten glass. C. S. STAFFORD. U. S. 1,443,767, Jan. 30. The walls of the furnace are formed of blocks or slabs of refractory material the outer faces of which are treated with waterproofing material, *e. g.*, brass, cement, or enamel, so that cooling liquid can be applied directly to them without damage. (*C. A.*)

46. Continuous cooling furnace for glass vessels. TAMESABURÔ YAMAMOTO. Japan. 40,047, Sept. 20, 1921. (*C. A.*)

47. Glass-melting furnace. SADAJIRÔ KÔNO. Japan. 40,098, 40,099, and 40,100 (additions to 35,150). Sept. 28, 1921. Diagrammatical descriptions. (*C. A.*)

48. Metallic decorations on china or glass. E. WARRIN. U. S. 1,438,799, Dec. 12. A design is printed upon the article to be decorated and the portion of the article not to be decorated is covered with an acid-resisting paste. The article is then immersed in HF soln. and the etched portion is filled with a Ag soln. which is subsequently fused into the material and then successively electroplated with Cu and Au. (*C. A.*)

Heavy Clay Products

49. White glazes for red burning clays. ANON. *Brick Pot. Trade Jour.*, **31**, 32–3(1923).—High opacity is necessary in glazes to cover the red body of the ware. This opacity may be produced with SnO_2. To prevent glazes rich in SnO_2 from peeling or crazing, the clay must contain at least 30% $CaCO_3$. For such clays the glaze must be fully matured at cone 05a (1000°C). Two glazes are available, a raw glaze rich in galena and a fritted glaze which is preferable because it is superior in quality. A raw glaze suitable for this purpose is as follows: Tin ashes 43, galena 32, and flint 25. Good fritted glazes are as follows:

	Frit				
	A	B	C	D	E
Feldspar	32	..	..	..	7
Cryst. Borax	27	..	..	..	..
Boracic Acid	..	..	..	1	..
Whiting	6	..	8	..	..
Red Lead	23	39	31	64	..
Flint	12	36	41	25	33
Tin Oxide	..	9	14	..	..
Potash	..	16	..	..	..
Soda Ash	..	..	6	..	14
China Clay	..	..	..	10	6
Tin Ashes	..	..	..	..	40
	Mill Batch				
Frit	100	..	100	100	..
China Clay	7	..	13	4	..
Whiting	..	..	..	1	..
Red Lead	..	..	..	1	..

Glazes A and D contain no Sn and are therefore less opaque than they might be, yet are suitable for purposes where great whiteness is not required. They are sufficiently fusible to enable one to add 10% SnO_2 if desired. H. G. S.

50. Burning bituminous shale. ANON. *Brit. Clayworker*, **31**, 317–18(1923).—The addn. of sand increases the porosity and greatly facilitates the burning since it aids the combustion of the carbonaceous matter without any serious risk of spoiling the brick. The critical period is between the dullest visible red to a bright red heat. The air supply should be carefully controlled at red heat. If the air supply is too great it will increase the temp. too rapidly vitrifying the surface and thus causing the same trouble that an insufficient supply of air does. The brick should not be fired above red heat until all of them have become oxidized as detd. by draw trials. Brick made of bituminous shale can be fired satisfactorily in a continuous kiln, provided they have a sufficient number of chambers. With great care a 12-chamber continuous kiln can be used, but not economically, and kilns with 18 to 25 chambers are much more suitable. At least 4 chambers should be preheated by waste gas and if this number can be increased to 6 chambers, it is better. Allowing 2 chambers for smoking, 1 being filled, 1 being emptied, and 6 chambers cooling gives a total of 17 chambers, but if the brick are to be thoroughly well burned it will usually be necessary to have 2 chambers at full fire thus making 18 chambers a minimum. Some shales require as many as 10 chambers in the preheating zone. Other shales are so rich in bituminous matter that they can be burned in continuous only when the various chambers in the kiln can be worked independently. H. G. S.

51. Salt glazing brick. ANON. *Brit. Clayworker*, **31**, 356–7(1923).—The brick to be salt glazed may be made (*a*) by hand and allowed to stiffen on a drier floor, (*b*) by the wire cut process and then repressed, (*c*) by the stiff plastic process and (*d*) by the semi-dry process. The brick should be placed in the kilns in a careful and systematic manner in such positions that the faces and ends to be glazed are exposed to the atmos. of the kilns, while all other faces and ends may be "covered" by placing them in close contact with one another. There must be sufficient open space for the salt to have ready access to the bricks or the glazing will be imperfect. Some firms prefer to arrange the bricks in narrow walls or blades about 10 in. wide, while others arrange them in the form of a checkerwork or honeycomb. The salt glazing is accomplished in a manner similar to that used for glazing sewer pipe. The amt. of salt required varies with the clay, but with care 10 to 20 ozs. per cu. ft. of kiln capacity will suffice. H. G. S.

52. Brick roads for Britain. A. E. BROWN. *Brit. Clayworker*, **31**, 346(1923).—The subject was dealt with by Mr. Brown before the Inst. of Clayworkers (London). The transformation in character of road traffic and its increased volume during the last few years has changed the problem of road construction considerably. The change is manifested in reduction of horse-drawn traffic, increase of motors, increase in axle load and speed. The essential properties necessary to stand up against these changes are: (1) durability, (2) foothold, (3) ease of repair, (4) economy of maintenance. Roads carrying large motor traffic are subjected to shock caused by the increased axle load accompanied by increased speed, and also to attrition of its surface due to the physical effects of the pneumatic tires. Asphalt and tar macadam do not stand the strain of this double attack very long, and repair is necessary much sooner than would be credited. B. then explains the advantages of the brick road, referring to many examples in Amer. roadmaking. In durability it comes higher than any other with the exception of the granite set road which however, comes lower in the attrition test. Vitrified brick, hard and dense in quality is the ideal material although others have been used with satisfaction and the only physical test of any value is the standard rattler test used in Amer. but unknown in Eng. In the test the ideal is that the bricks submitted

to it should not lose more than 22 to 24% of weight, but bricks losing as much as 39% have been used satisfactorily. According to all Amer. authorities the brick road is superior to any other and its qualities are: (1) It is impermeable; (2) durable; (3) gives perfect foothold; (4) requires the least tractive force; (5) is suitable for all gradients; (6) and for all classes of traffic; (7) is practically noiseless; (8) is easily cleaned; (9) yields no mud or dust; (10) is easy to repair; (11) is cheapest by far to maintain; (12) can be laid with smaller camber; (13) is not influenced by climate; (14) is easily opened and reinstated when pipes, etc., have to be laid; (15) improves with use. The standard rattler test is explained and also methods of laying; approx. cost of a sq. yd. of brick paving is 8s. 9d. as compared with 6s. 6d. for tar macadam and 10s. 6d. for asphalt carpet. The slightly greater cost is negligible when compared with the shorter life and greater maintenance cost of the latter two. B. concluded with the suggestion that an association be formed to conduct expts. in Eng. and a discussion followed by the members of the Inst. O. P. R. O.

53. Glazing bricks. ANON. *Raw Materials Rev.*, **2**, 109(1923).—Under a Ger. specification, a coating-compn. to be applied to concrete, sandstone, clay, brickwork, or the like, consists of water and finely sifted cement, with a water-proofing ingredient, such as a bituminous, resinous, or wax-like substance or a metallic soap. Suitable soaps are obtained by using a mixt. of alk. soap with ammoniacal zinc soln. or ammoniacal or alk. soln. of copper, lead, tin, chromium, or aluminium hydroxides, or a mixt. of calcium suboleate and aluminium sulphate. O. P. R. O.

54. New brick plant. ANON. *Brick and Clay Record*, **62**, 509–13, 516–17(1923).—Diagram and photos of new brick plant of Gloninger and Co., Vanport, Pa. Plant produces waterproof brick. Description of unique efficiency layout, incorporating automatic clay crushing and grinding; vibrationless brick machine unit; handling of drier cars without switch, turntable or transmission; signal system in drier and remarkable storeroom. J. W. H.

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55. Clay flux for brick compositions. B. SCHMIDT. U. S. 1,442,585, Jan. 16. A flux for use with clay in brick manuf. is formed from pulverized glass, salt, pulverized granite and oxidized Zn. (*C. A.*)

56. Clay pavement. H. L. HADLEY. U. S. 1,441,342, Jan. 9. The surface of a formed clay pavement is fired to harden it. (*C. A.*)

Refractories

57. Quartz (Norway). OLAF ANDERSEN. *Norges Geologiske Undersokelse.*, **103**(1922).—Quartz, comparatively pure, occurs in S. Norway, the quantity available by quarrying from surface now exposed is estd. at from 4 to 500,000 T. Analyses are given. Assays show that two out of 7 samples contained insignificant amts. of gold and silver. O. P. R. O.

58. Bauxite: Occurrence, mining and uses. RAYMOND B. LADOO. *Eng. Mining Jour.*, **114**, 805–9(1922).—Arkansas produced (1920) over 90% of U. S. bauxite or about 60% of the world output for that year. Manufacture of abrasives and refractories consumes from 10% to 20% of domestic product. Bauxite (high grade) melts at 1820°C, Al_2O_3 at 2050°C. Bauxite brick are chem. inert at high temp. Alundum, adamite, alowalt, aloxite, metalite, rex, oxalumina, are some of the trade names of more or less pure Al_2O_3 produced from bauxite. La Farge cement, fused cement, "cement fondu" are names for high alumina (40%) quick setting and hardening cements. S. L. G.

59. The marketing of chromite. EDWARD SAMPSON. *Eng. Mining Jour.*, **115**, 356–8(1922).—Chromite is the only ore of chromium and its compds. Theoretically,

Cr_2O_3 68%, FeO 32%; Al_2O_3 and Fe_2O_3 may partly replace Cr_2O_3 and MgO and FeO. Little or no chromite is normally produced in U. S. New Caledonia, Rhodesia, India, main producers, Turkey in Asia, Russia and Greece less important. Refractories consumed 35% of chromite brought into U. S. in 1922. Chemicals 25% and ferro chrome 40%. Chromite for refractories should be low in silica. Analyses of representative ores given. Marketing, prices, production and imports charted 1909–1922.
S. L. G.

60. The durability of refractories. W. J. REES. *Pottery Gaz.*, **48,** 453–8(1923).—A general paper on refractories, a considerable portion of which advocated the use of silica brick for construction of the by-product coke oven. A discussion followed the paper.
J. W. H.

61. Glass house refractories. ANON. *Pottery Gaz.*, **47,** 727, 729, 731, 733, 735 (1922).—A lengthy discussion of failures in refrac. materials for glass house use.
J. W. H.

62. Dolomite (Norway). OLAF HOLTEDAHL AND OLAF ANDERSEN. *Norges Geol. Undersokelse.*, **102**(1922).—Dolomite, pure and fine grained, occurs in N. Norway. Preliminary expts. on burning dolomite are described. Small charges of dolomite were heated elec. to observe the degree of sintering attained and the dusting due to impurities of silicates or quartz in the dolomite. Each example was examd. under the microscope before and after the ht. treatment: htg. for 2–5 hrs. at about 1400°C did not produce any effective sintering of the varieties of pure dolomite. Dusting had no harmful effect in the samples examd. Structure and size of grain of the raw dolomite had no predominating influence on the corresponding properties of the burned product. The mixt. of lime and magnesia forming the results of the burning were always very fine grained. A brief review is given of the more promising methods for utilization of dolomite as an industrial raw material. Among the methods mentioned is elec. sintering and melting of dolomite exptd. on by a Norwegian firm, Ostlandske Stenexport Co. References are given to U. S. Bur. of Mines pubs. It is briefly indicated which methods might be used in attempting the exploitation of dolomite in Norway, the most recommendable way seems to be to try one of the methods suggested for the sepn. of lime from dolomite possible in connection with elec. sintering or melting of raw dolomite.
O. P. R. O.

63. Durability of refractories. W. J. REES. *Colliery Guardian*, **125,** 515.—R. brings out the foll. points: The importance of refrac. materials in present-day civilization is now accepted. Much less than a generation ago it could be said that the tech. study of the use of refrac. in this country was on a much lower plane than in Ger., but during the last 10 yrs. the leeway has been made up. Refrac. is now a final subject for degrees at the Univ. of Sheffield and manufacturers are stressing the need for research. The life of a fur. or fur. lining should not be measured in days, wks., or mos., or even in heats; the factor to ascertain, and the only sound basis on which to make comparisons, is the cost of refractories per T. (or other unit) of salable product. "Failure" might be loosely defined in terms of a life much shorter than the average, or in terms of a much higher cost in refractories per unit of satisfactory product. An analysis of "failures" which had come under the author's notice enabled the placing of them into four classes: (*a*) Unsatisfactory quality, including lack of uniformity of quality. (*b*) Faulty selection owing to the absence of knowledge of the conditions to be met. (*c*) Faulty treatment of the material in service, due either to accident, carelessness, or ignorance. (*d*) Failure to allow a margin so that abnormal conditions of short duration may be withstood, *i. e.*, "factor of safety." Failures of the first 2 classes should be entirely eliminated, and of the third, could be also to a marked extent, by educ. of charge hands. The standard methods of testing proposed by the refractories section of the Ceram. Soc. are well

known and widely used but the provisions of other tests which give measurable results and the amplification of some of the existing tests is desirable. The available methods to det. the resistance of refrac. to abrasion and slag attack are as yet purely comparative. It can be roughly detd. by drilling a hole in the brick, filling it with the slag or ash and heating under pre-detd. conditions. The brick is then cut or broken across the hole and the extent of corrosion or depth of penetration observed. A better method is to cement to the face of the brick a clay ring and fill this with the slag or ash as the face or skin of the brick is not then removed and its lower porosity may retard the speed of corrosion. Results of comparative tests of several brick are then given in detail. When the brick are being used for the building of coke ovens, if the coals, which are being coked are non-salty, satisfactory durability is obtained from either fire clay or semi-silica brick, but there is definite evidence from Amer. practice, that a silica brick oven construction renders possible the use of higher coking temps. and a larger output from an oven of given size without any sacrifice of by-products. Even the highest grade of fire clay brick will deform under load at a temp. well below its normal softening point, while a highly converted silica brick of low porosity will carry load almost up to its fusion point. At high coking temps. therefore the durability of adequately made silica brick will exceed that of brick made wholly, or in part, of fire clay. O. P. R. O.

64. Molding sands. W. J. REES. *Metal Indus.*, **22,** 197(1923).—The principal points considered in the investigation of molding sands to make possible specifications or standards so that systematic definite lab. tests would det. the suitability of sands for various classes of work were: The chem. and mineralogical compn.; the texture or mech. compn.; the bonding power or strength; the permeability and porosity; the refractoriness; the durability. The ultimate analysis of a sample of the sand was the first consideration, the ordinary methods of silicate analysis should be used (Standard Methods of Testing, *Trans. Ceram. Soc.*, **1919**). A sample of sand was ground to an impalpable powder in an agate mortar, and then one g. was weighed into a platinum basin; 15 to 20 cc. of hydrofluoric acid and 3 cc. of strong sulphuric acid were added and the mixt. gently stirred with a platinum wire. Gentle evapn. to dryness on a sand bath till all evoln. of fumes had ceased then eliminated the whole of the free and combined silica as silicon fluoride, leaving all the bases as sulphates. This residue of sulphates was weighed, and approx. $^1/_3$ of this wt. represented the wt. of basic oxides present in the sand. The limits in chem. compn. would depend on the purpose for which the sand was intended. Many of the properties of a molding sand depended more on its mineralogical compn. than on its ultimate analysis. The water holding capacity was dependent on the propn. of colloidal matter present. A distinguishing feature of molding sands was their capacity for holding water without becoming really wet. The texture or mech. compn. or grading of the sand was detd. by sieving and elutriation methods. In the sand grade, the silt grade and the clay grade, it was in the clay grade that the bonding power was concd. The coarser grades were pure quartzose sand, while the other minerals were all concd. in the finer grades, the finest or clay grade having the compn. of a ferruginous clay. PROF. BOSWELL'S method for detg. the transverse test and his method for measuring the permeability is also given; variations of from 50 to 500 sec. were obtained in this test, depending on the grading of the sand and the propn. of clay or other fine bond present. The ingenious method of measuring permeability devised at the Canadian Mines Branch is described, which eliminates some of the possibilities of error of the air method. The refractoriness of the sand might be detd. by the ordinary standard method, in which a small cone of sand was heated in an ordinary atm. along with standard cones. The durability of a sand was an impt. factor in its economic use, this could be tested under actual working conditions. Synthetic molding sands used in Gr. Brit. and Amer. were discussed. Rees believed that it would

be possible to make a synthetic sand which would give results in the steel foundry quite equal to those obtained with imported molding sands. Synthetic molding sand was prepd. from a high silica sand with the addn. of some material which would give it the necessary bond. The subject needed further investigation to perfect the synthetic sand, which when accomplished would make standardization possible, and variations practically eliminated. The question of the use of synthetic sand and the possibility of the use in them not only of clay, but also of starch, flour, and many of the carbohydrates required extended study. Rees mentioned the addn. of an exceedingly small propn. of alkali to the clay which had the effect of deflocculating it. Crushing the quartz grains should be avoided, and he thought that this deflocculating action pointed the way to a method of adequately mixing sands and clays. O. P. R. O.

65. Slag action on refractory linings. H. HIRSCH. *Tonind. Ztg.*, **47**, 152–4(1923).—The influence of 9 different slags on different refrac. were studied. It was found that the porosity of the brick is more impt. than the Al_2O_3 content and the softening point. Brick made of fused clay (containing 70% Al_2O_3) were practically unaffected by slag action. Refractoriness is not important as long as the brick withstands the temp. at which they are used. Brick to resist slag should have a softening point above cone 28, compress. strength above 80 kg./cm.^{2}, the shrink. upon reheating to cone 14 should be less than 2% and should be dense and non-porous. H. G. S.

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66. Refractory material for furnaces. C. A. SCHARSCHU. U. S. 1,444,527, Feb. 6. A refractory compn. is formed in part of a coherent mixt. of crystd. MgO, calcined MgO of lower d. and C and in part of a subvitreous monolithic layer of MgO particles bound together by sublimed MgO. This layer has a mass d. of 3.5–3.6 and is so hard that it has a metallic ring even at elec. furnace temps. and it undergoes no material expansion or contraction at temps. up to 1800°. (*C. A.*)

67. Bonding carbide grains with ceramic material. M. F. BEECHER and M. C. BOOZE. U. S. 1,444,162, Feb. 6. Grains of Si carbide or similar material are mixed with a ceramic binder such as a plastic clay compn. and the mixt. is fired in the presence of reducing gases or other medium which will prevent oxidation. (*C. A.*)

68. Electric furnaces. W. E. MOORE. Can. 226,309, Nov. 21, 1922. In the manuf. of steel or other metals in an elec. furnace current is supplied to the bath from a plurality of arcing electrodes and the amt. of current passing through the bath is varied by varying the length of one or more of the arcs with respect to the others. The melt may be produced by means of a high voltage and long arc and refined with substantially the same current with reduced voltage and shorter arc. (*C. A.*)

69. Electric furnaces. W. E. MOORE. Can. 226,310, Nov. 21, 1922. In the treatment of steel or other metals in an elec. furnace supplied with power from a multiphase circuit, a circulation of the bath is produced by a rectified current from the current of sep. phases. Two or more currents of different phases may pass from the electrodes to the bath and the amt. of current passing through the bath may be varied by unbalancing the resistance of the arcing circuits. (*C. A.*)

70. Electric metallurgical furnaces. W. E. MOORE. Can. 226,311, Nov. 21, 1922. The furnace has a chamber adapted to contain metal, an elec. arc in the upper part of the chamber for heating the metal, a pair of extensions on the furnace bottom angularly disposed with respect to each other and to the central axis of the furnace. Each extension has a channel in the form of a loop of elongated transverse section which gradually expands upwardly into communication with the main chamber and an elec. heating element around which each extension is looped. (*C. A.*)

71. Electric furnace. F. T. SNYDER. Can. 226,318, Nov. 21, 1922. A furnace

having refractory heat insulating walls and an arc resistor with a negative temp. coeff. is started with a long arc at high voltage and small current and the heat is furnished with a short arc at low voltage and high current. (*C. A.*)

72. Electric furnaces. I. RENNERFELT. Can. 226,027, Nov. 14, 1922. The furnace has a plurality of electrodes suspended into a projection from the bottom of the furnace under the electrodes, a conducting layer of C on the projection forming contacts for the ores formed, and a channel along the heating zone of the arcs for receiving the material to be heated. (*C. A.*)

73. Electric reverberatory furnace adapted for smelting ores. R. M. KEENEY. U. S. 1,438,381, Dec. 12. (*C. A.*)

74. Induction furnaces. J. R. WYATT. Can. 226,811, Dec. 5, 1922. The furnace has a pool for molten metal, walls forming a closed channel below the pool, the channel communicating with the pool at two points and having parts of the channel forming an acute angle at a distance from the pool and a transformer for which the metal in the channel acts as secondary, setting up motor effect in the channel. Cf. *Ceram. Abs.*, **1** [11], 279(1923). (*C. A.*)

75. Refractory ceramic ware. J. A. JEFFERY. U. S. 1,438,599, Dec. 12. A refractory material adapted for furnace linings or saggers is formed from a raw batch comprising a granular refractory material such as Si carbide and Edgar's plastic kaolin or a clay of like character. (*C. A.*)

76. Bonded alumina refractory material. M. F. BEECHER. U. S. 1,439,286, Dec. 19. Cryst. Al_2O_3 grains contg. slag and oxidation impurities are integrally united by a vitrified ball clay material so that the grains are substantially in contact and shrinkage of the article during firing is minimized. Articles such as fire bricks may be thus formed and are fired above cone 12 until any permanent vol. change due to expansion of the material has been completed. (*C. A.*)

77. Refractory materials. E. D. FROHMAN. Brit. 186,968, June 10, 1921. A refractory compn. consists of finely divided fire clay, a siliceous refractory substance such as ganister or asbestos, and a vegetable substance which acquires binding properties when moistened with H_2O, such as sulfite pitch (a by-product from the manuf. of sulfide pulp), dextrin, or gum arabic. The compn. is mixed with H_2O when required for use. (*C. A.*)

78. Tilting oil-fired crucible furnace adapted for melting metals. J. A. GASKILL. U. S. 1,439,409, Dec. 19. (*C. A.*)

79. Material for furnace walls. J. H. GRAY. U. S. 1,439,410, Dec. 19. Bricks for furnace walls are formed mainly of a carbonaceous material such as calcined anthracite mixt. with a facing layer of another refractory material more resistant to oxidation, *e. g.*, MgO, clay and SiO_2, Cr ore or zirconia. (*C. A.*)

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80. Refractory materials. Z. OLSSON. U. S. 1,442,413, Jan. 16. A refractory material adapted for crucibles or furnace linings is prepd. from bauxite 95 and bentonite 5%. (*C. A.*)

81. Refractory articles containing zircon. H. H. BUCKMAN and G. A. PRITCHARD. U. S. 1,440,766, Jan. 2. Muffles, crucibles or similar refractory articles are formed of zircon and carborundum. (*C. A.*)

82. Refractory articles containing zircon. H. H. BUCKMAN and G. A. PRITCHARD. U. S. 1,440,657, Jan. 2. Retorts, muffles or other refractory articles are formed of zircon and SiO_2 or clay. Cf. *Ceram. Abs.*, **1** [3], 68(1922). (*C. A.*)

83. Refractory material for high-temperature apparatus. H. B. CLAPP. U. S. 1,437,584, Dec. 5. A mixt. of chromite 85 and ferro-Si 5 parts reduced to small particles

and associated with a binder, *e. g.*, Na silicate soln. 10 parts, is used for making linings of portable *gas producers* or other articles exposed to high temps. (*C. A.*)

Whiteware

84. The crazing of English earthenware. H. ELWOOD. *Pottery Gaz.*, **48,** 104–6 (1923).—The author considers bulk of crazing of earthenware bodies due entirely to variations in *body* compn. 80 bodies were made and dipped in a standard glaze. All bodies were glost fired at cone 01, and the biscuit firing was varied as follows: cones 04, 01, 2–3, 3–4, and 8–9. For this work the glaze used had the compn.:

$$\left.\begin{matrix} 0.070\ K_2O \\ 0.233\ Na_2O \\ 0.400\ CaO \\ 0.290\ PbO \end{matrix}\right\} \quad 0.251\ Al_2O_3 \quad \left\{\begin{matrix} 3.164\ SiO_2 \\ 0.402\ B_2O_3 \end{matrix}\right.$$

The author concluded the best compn. for a safe body for practical working was 75.24 SiO_2; 20.59 Al_2O_3; in the fired condition, 4.18 bases. Before firing the composition was 71.10 SiO_2; 19.50 Al_2O_3; 3.97 bases 5.42 loss on ignition. Body was safe in firing range from cone 01 to cone 9, and porosity varying from 27.63 to 2.25%. It met with requirements of practical potting, as regards plasticity and safety during firing up to, say, cone 6, which was the limit required in hardest earthenware fire. The recipe for body is 40 clay; 50 flint; and 10 feldspar. Using a normal variety of flint and a mixed Cornish stone in place of the feldspar the batch is thus: 26 ball clay; 22 china clay; 19 stone; and 33 flint. However, the author pointed out that alteration of compn. of only one material in the mixt. may cause trouble. This was demonstrated by making up an earthenware body of definite compn., but using 64 different varieties of china clay. Fired at ordinary earthenware biscuit and glost temp. he obtained both crazing and peeling. J. W. H.

85. The atmospheric conditions in potters' shops and the efficiency of various types of drying stoves. H. M. VERNON. *Pottery Gaz.*, **47,** 1825–7(1922).—Av. temp. of potters' shops is about 67–70°F in winter and 75–82°F in summer as compared with usual workshop which is maintained at 60–65°F in winter. However, relative humidity, because of drying moist clay, is not high for the reason that the high temp. permits carrying more moisture without becoming half saturated. Author concludes, from evidence obtained, that potters are correct in maintaining high temps. are requisite for drying moderately sized articles and molds. It is obvious, however, a certain amt. of ventilation is necessary. The drying stoves investigated had enough leakages to insure fair ventilation. Attempts should be made to convey heated air to atm. but such installations require an independent heating system in the shop. J. W. H.

86. Chemical porcelain. G. WHITE. *Pottery Gaz.*, **47,** 566–7(1922).—Hypothesis regarding the fracturing of chem. porcelain is given. Chem. porcelain being a supercooled liquid; the author advances the theory that fracturing is result of devitrification or an attempt at crystn. under *stress*. The requirements for production of chem. porcelain (1) body mixt. should be of such nature to be capable of as complete devitrification as possible, (2) adequate process of devitrification should be applied. In Worcester mixes max. crystn. occurred in a burning of 84 hrs. of which 30 hrs. consisted in heating from 1300 to 1400°C. In this period max. production of sillimanite occurred, advancing devitrification to a limit at which liability to further crystn. was sufficiently removed to make a high grade chem. porcelain. A method for measuring degree of crystallinity and ht. change resistance is needed badly to attack the problem adequately. J. W. H.

87. Pyrometers as applied to pottery industry. C. E. FOSTER. *Pottery Gaz.*, **48,** 441, 443, 445–6(1923).—A lengthy and general address bearing upon diff. types

of pyrometers, development of thermo-elec. pyrometer, base and noble metal thermocouples, functions of the protection tube or sheath, location of thermocouples and Seger cones. J. W. H.

88. Porcelain manufacture in Indo-China. ANON. *Brit. Clayworker*, **31**, 371.—The beginning of national porcelain industry at Tonkin is announced. It is due to the initiative of an Annamite who recently studied the industry in France and now employs at the Hap Loy works some 350 men. Indo-China itself promises to be the principal sales outlet. The local Gov't is supporting the venture by giving the firm an order for electric insulators required by the Post Office. Molds for the manuf. of European table and toilet services are on their way out, and the owner intends to adopt Japanese and Chinese styles for wares intended for the Annamite population. O. P. R. O.

89. Scientific aspects of China's ancient pottery industry. G. WANG. *Science* (China), **6**, 869–82(1921).—The manuf. of glazed ware in China dates from about the year 100 B. C. The excellence of the early pottery ware was due to the use by the Chinese of a feldspar glaze and high temps. Cu, Fe and Pb colors were largely used. There is no evidence of the use of Cr or U compounds. A type of furnace built on the principle of the Hoffman Ring furnace has been in use for at least 1000 years.

W. H. A. (*C. A.*)

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90. Fused ceramic bearing. T. G. MCDOUGAL and S. J. MCDOWELL. U. S. 1,438,188, Dec. 12. Annular bearings for speedometers or other instruments are formed of a fused ceramic material prepd. from a mixt. of feldspar and clay. (*C. A.*)

91. Crucible of chemical porcelain. H. D. LILLIBRIDGE. U. S. 1,441,690, Jan. 9. The pat. relates to the curvature of the wall of the crucible, which flares outwardly at its top. (*C. A.*)

92. Ceramic electric insulating material. J. A. JEFFERY. U. S. 1,438,598, Dec. 12. Cf. *Ceram. Abs.*, **1** [8], 211(1922). Ceramic insulating material is formed from a raw batch composed of a calcined mixt. of clay, alumina and talc or feldspar mixed with raw clay. The clay of the calcine is selected so that it matures at the temp. of the formation of sillimanite and the raw clay is of such a nature that when heated by itself it matures at the temp. at which the ceramic mixt. matures. (*C. A.*)

93. Electrically heated ceramic ware. A. STEINHARDT. Brit. 188,050, July 28, 1921. In the construction of an electrically heated ceramic vessel, the vessel after being fired is fitted with a heating resistance provided with terminals, the heating body being then covered with ceramic material having the same coeff. of expansion as the resistance and composed of the same materials as the vessel but with the addn. of fluxing materials which lower its sintering temp. below that of the heating resistance, after which the entire app. is again fired. The vessel is essentially made from kaolin, feldspar and quartz and the fluxes added to form the material may consist of the oxides of Mg, Na, Pb and B together with a little Na chloride and waterglass. For a vessel composed of clay 48, quartz 40, feldspar 12%, and provided with a heating body of nichrome the material may have the following compn. by wt.: Na_2O 0.1, K_2O 0.3, MgO 0.4, CaO 0.2, Al_2O_3 0.4, SiO_2 2.6 parts, and 4 parts of the material used in making the vessel. Such a compn. may be obtained by using borax 120, MgO 50, chalk 40, sand 70, Na_2CO_3 20, feldspar 100, PbO 40, zettlitz kaolin 100, fluorspar 60, Na_2SiO_3 50 parts, and 150 parts of glaze appropriate to the porcelain mixt. The terminals are in a holder and are preferably arranged side by side at 90° to the handle. In a modification the vessel has a raised bottom with a spiral groove on the underside in which the heating wire is situated. (*C. A.*)

94. "Safety-tread" ceramic tile. G. N. JEPPSON and M. F. BEECHER. U. S. 1,445,083, Feb. 13. Vitrified tiles of ceramic material are formed with cryst. granules

of Al_2O_3 or other abrasive material integrally embedded within the superficial or tread portion of the tile. (*C. A.*)

Equipment and Apparatus

95. The "Dorr" mill. A. S. W. ODELBERG. *Pottery Gaz.*, **47,** 1671, 1673, 1675 (1922).—Description of a continuous grinding system at Gustafsberg for grinding a mixt. of equal parts of calcined quartz and flint. Capacity at present operation 7.2 T. per 24 hrs. or 11 lb. per min. dry wt. Thickness of pulp is 1.6 sp. gr. or 32 oz. per pint. Pebbles were worn away at the rate of 300 lb. per 24 hrs. Mill run at 35 r. p. m. Output of one unit of continuous system is equal to 5 times the output per unit compared with batch grinding. J. W. H.

96. A new viscosimeter for very viscous substances. R. FISCHER. *Seife,* **45,** 483–4(1922); *Chimie et industrie,* **9,** 89(1923).—A jacket in which water circulates at 62° surrounds a tube contg. the sample, the temp. of which remains const. at 58°. The time required for an Al ball to fall the length of the tube is noted with a stop watch. Pure glycerol is taken as standard, and the viscosity is expressed as the ratio of the time of fall with the sample to that with glycerol. With dark or opaque liquids the Al ball is made to close an elec. circuit and light a lamp. A. P.-C. (*C. A.*)

97. Elastic column dynamometer for hardness testing. H. A. HOLZ. *Chem. Met. Eng.,* **28,** 269–70(1923). Illus. E. J. C. (*C. A.*)

98. Some notes on the evolution of the konimeter. R. A. H. FLUGGE-DE SMIDT. *J. Chem. Met. Mining Soc. S. Africa,* **23,** 77–86(1922). E. J. C. (*C. A.*)

99. New calculation for the determination of the strength of flanges. OSWALD KLINCK. *Chem. App.,* **10,** 3–4(1923).—Mathematical formulas. J. H. M. (*C. A.*)

100. Personal equation errors in optical pyrometry. GEORG KEINATH. *Stahl u. Eisen,* **43,** 9–12(1923).—Comparable temp. measurements by unskilled operators using the total, and the partial radiation, and disappearing filament optical pyrometers from 600° to 1500° show the disappearing filament optical pyrometer to be most serviceable. Facilities in operation permit a rapid proficiency and an accuracy of ±20° from 600–700°, ±15° at 100° and ±10° at 1500°. Above 1500° the radiation pyrometer is used. W. A. M. (*C. A.*)

PATENTS

101. Tubular resistance electric furnace. G. M. LITTLE. U. S. 1,443,581, Jan. 30. A furnace adapted for baking green resistance rods is formed of tube sections (of graphite or other resistance material) held together end to end under pressure and surrounded by heat-retaining material, *e. g.,* lampblack and asbestos. (*C. A.*)

102. Electric resistance crucible furnace. C. H. CARPENTER. U. S. 1,444,948, Feb. 13. Cf. *Ceram. Abs.,* **1** [9], 234(1922). (*C. A.*)

103. Tilting electric arc crucible furnace for smelting silver ore. R. M. KEENEY. U. S. 1,443,024, Jan. 23. (*C. A.*)

104. Tilting electric furnace adapted for melting scrap iron. D. DELUCA. U. S. 1,442,925, Jan. 20. (*C. A.*)

105. Electric inductive furnace. G. H. CLAMER and J. R. WYATT. U. S. 1,444,584, Feb. 6. The furnace has a resistor dome and is adapted for melting metals. (*C. A.*)

106. Electric arc furnace. F. A. J. FITZGERALD. U. S. 1,443,816, Jan. 20. The pat. relates to the manner of mounting opposed horizontal electrodes which are adjustable and extend through the side walls of the furnace. The furnace is adapted for use on single-phase current. Cf. *C. A.,* **17,** 371. (*C. A.*)

107. Electric arc furnace of the rocking type. W. E. MOORE, H. F. ALTER, E. A.

HANTF, J. R. ECKLEY and F. WRIGHT. U. S. 1,444,980, Feb. 13. The furnace is adapted for melting steel. (*C. A.*)

108. Rotating or oscillating electric furnace plants. A. H. PEERSON. Can. 228,203, Jan. 23, 1923. (*C. A.*)

109. Electric furnace. R. A. DRISCOLL. Can. 228,167, Jan. 23, 1923. An elec. furnace has a rotatably mounted inclined tube connected with an outlet in the furnace roof, means for rotating the tube, means for introducing charge materials into the upper end of the tube and auxiliary means for feeding material into the furnace. (*C. A.*)

110. Electric furnaces. F. W. SPERR and H. J. ROSE. Can. 227,463, Dec. 26, 1922. An elec. furnace for testing materials consists of a row of heating units forming a long narrow chamber to receive a testing tube and means for connecting the units in circuit progressively from one end to the other so as progressively to heat the sample of material being tested. The units are U-shaped, of refractory material wound with resistance wire. (*C. A.*)

111. Electric resistance furnaces. T. A. REID. U. S. 1,444,939–40, Feb. 13. (*C. A.*)

112. Electric resistance furnace. T. A. REID. U. S. 1,443,590, Jan. 30. Heating units within refractory walls include plates which are brought into operative position by a lateral and tilting movement. (*C. A.*)

113. Electric resistance furnace. G. M. LITTLE. U. S. 1,443,580, Jan. 30. The pat. relates to the manner of mounting and cooling the electrodes. The furnace is adapted for heating metals. Cf. *Ceram. Abs.*, **1** [6], 163(1922). (*C. A.*)

114. Apparatus for testing abrasives. L. RATNER and M. SCHWARZ. U. S. 1,444,803, Feb. 13. (*C. A.*)

115. Scleroscope. G. WIRRER and A. C. MOYER. U. S. 1,444,228, Feb. 6. The app. comprises a hammer moving in an open-ended tube with a cylinder and manually operated piston mounted on its upper end for actuating release mechanism for the hammer. (*C. A.*)

116. Scleroscope. R. HERRMANN. U. S. 1,444,606, Feb. 6. The device comprises a gravity-actuated hammer mounted with a driver device to return the hammer to its starting position. U. S. 1,444,607 relates to a similar app. adapted for testing the hardness of metals. (*C. A.*)

117. Apparatus for analyzing flue gases. R. F. MACMICHAEL. U. S. 1,443,492, Jan. 30. Flue gas and air are drawn by sep. suction fans through humidifying and temp.-controlling app. and the amt. of CO_2 in the flue gas is indicated by a recording drift gage depending on the differential pressures of the gas and air. (*C. A.*)

118. Apparatus for drying materials by steam and air currents. H. BENTZ. U. S. 1,436,142, Nov. 21. (*C. A.*)

119. Pyrometer of the potentiometer type. H. J. BLAKESLEE. U. S. 1,441,207, Jan. 9. (*C. A.*)

120. Ball testing apparatus for estimation of resiliency of metals, rubber or other materials. R. M. GASTON. U. S. 1,441,626, Jan. 9. A steel ball is held by a magnet and released from a definite height and allowed to fall upon the material under test and the rebound of the ball is noted. (*C. A.*)

Kilns, Furnaces, Fuels and Combustion

121. John Wright tunnel oven. ANON. *Pottery Gaz.*, **47**, 1538(1922).—Installation at British Pottery Co., Tunstall. Built on the car tunnel kiln principles; that is, stationary fires and moving ware. Kiln is over 200 ft. long, internal width is about 5 ft. and height from truck platform to crown of arch about 6 ft. Capacity of each truck,

about 50 saggers. Charging schedule is one car per hr. An elec. motor penetrates charging ram, the actual charging time is 1 min. Firing zone operates at 1200°C. Gas is supplied by a Horsehay producer and arrangements made for burning off tarry matter which may be deposited in the flues. Primary air is heated in brickwork, and secondary air is drawn through cooling zone. This air cools the ware in the saggers and in consequence is heated. Waste ht. is used for drying purposes in manuf. process. An inspection pit runs the entire length of tunnel under the trucks. Coal consumption is about 300 lb. per hr. Photographs accompany article. J. W. H.

122. The "Potter" kiln. ANON. *Pottery Gaz.*, **47,** 1535(1922).—Description and phot. of gas fired continuous kiln erected by Dean, Hetherington & Co. at Alexandra Works of Domestic Porcelain Co., Fenton. Kiln consists of 16 chambers in a double row of 8 with a gangway between. Kiln is fired with a No. 4*a* Duff producer, with gas and air ports in central opening between the 2 rows of chambers. This opening is fitted with shelves to dry saggers from the green state by means of waste ht. from various chambers as they are fired. All chambers are connected to a stack 135 ft. high. Gas and air ports are underground. Saving of fuel claimed as 50% and labor as 25%. Quality of fired ware up to standard. Highest sagger is not more than 12 ft. above level of chamber. J. W. H.

123. Electric resistance furnaces. C. R. DARLING. *Electrician*, **90,** 168(1923).—Advantages of elec. heating *vs.* gas heating are enumerated. Ni-Cr alloys, in the shape of wire and ribbon, are widely used. They can be operated at 1000° for long periods of time without deterioration. For high speed steel treatment a resistor alloy that will operate at 1300° to 1400° is needed. D. believes that "a cheap alloy capable of withstanding 1800° without oxidizing" could be made. C. G. F. (*C. A.*)

PATENTS

124. Muffle furnace. A. McD. DUCKHAM. U. S. 1,436,582, Nov. 21. An annular muffle furnace is built with a traveling platform to which material may be supplied and from which the residue of the material may be removed without interrupting the operation of the furnace. (*C. A.*)

125. Rotary horizontal furnace or kiln adapted for heating granular or pulverulent material. A. DWORZAK. U. S. 1,443,529, Jan. 30. The kiln is surrounded by concentric chambers for hot gases and cooling water. (*C. A.*)

Geology

126. Feldspar. ANON. *Can. Min. Jour.*, **44,** 237(1923).—Potash feldspar (orthoclase and microcline) which occurs in abundance in several parts of Canada, contains in its pure state 18.4% alumina and 16.9% potash, with a combined potential value slightly below that of the same constituents in alunite. Should an economical process for resolving potash feldspar into its constituent parts be found, the comparative accessibility of Canadian feldspar deposits will put them in position for manuf. Large deposits of anorthite (lime feldspar) which contain in the pure state 36.7% alumina, the remainder being silica and lime, are also available in Canada. It is possible that some simple process may be found whereby this alumina may be made commercially available. O. P. R. O.

127. Note on the formation of the Alsatian potash basin. RAOUL LEBRUN. *Bull. Soc. ind. Mulhouse*, **88,** 508–11(1922).—The basin consists essentially of 2 potash layers which are worked and between which are: an unworked deposit of high-grade K salt 0.80 m. thick, a layer of almost pure K salt 0.30 m. thick and 1.80 m. above the first and lying between 2 layers of shale, layers of shale and salt of varying thicknesses, a 10-m. layer of rock salt just below the upper of the two worked deposits, and above and

below the potash layers are alternating layers of rock salt and of shale. From a detailed examn. of the fissures in the shales, L. concludes that the K deposits were not formed in a continuous manner but are the result of the leaching of considerable dry marine deposits, the waters having flowed to what is now the Alsatian basin, where they were evapd. A. P.-C. (*C. A.*)

128. Report of the work of the ceramic division. JOSEPH KEELE. Can. Dept. Mines, *Summary Report*, No. **574**, 55–71(1922).—The Canadian deposits of brick, fire, pottery and special clays are described. L. W. R. (*C. A.*)

Chemistry and Physics

129. Action of heat on kaolins, clays. ANON. *Jour. Soc. Chem. Indus.*, **42**, 184A.—Samples of kaolins, clays, bauxites, infusorial silicates, etc., have been submitted to heating under varying conditions over a wide temp. range. The results show that plastic ceram. materials under the action of heat, undergo first a hardening without dehydration or change in vol.; this hardening is due to the partial peptising of the colloids which they contain. After dehydration and above 700°C phys. changes occur accompanied by shrinking, and the substances continue to harden, and at the same time the colloids disappear. Non-plastic ceramic materials only harden once, at about 1000°C, after their complete dehydration has occurred at 650–700°C. The phenomenon of peptisation of colloids plays a considerable part in the ceram. indus. and particularly in the industries based on baked earths. (*Comptes rend.*, **176**, 91–3(1923).)
O. P. R. O.

130. Coal. A. C. FIELDNER, *et al.* *Proc. Am. Soc. Testing Materials*, **22**, I, 459–62(1922).—Report of Comm. D-5. The micropyrometer method for coal ash fusibility (*C. A.*, **16**, 3381) was compared with the standard gas-furnace method (*C. A.*, **14**, 1028). The 2 methods checked fairly well on most coal ash fusing below 2600°F by the gas furnace method, but very refractory ash, fusing above 2600°F by the same method, gave much lower results by the micropyrometer method. Tentative revision was made of standard methods of lab. sampling and analysis of coal (D22-21), and of the tentative method of test for fusibility of coal ash (D22-19T). J. L. W. (*C. A.*)

131. The density of a mixture of oxygen, carbon monoxide and carbon dioxide. Relations between the volume per cent and weight per cent. PAUL SCHREIBER. *Z. angew. Chem.*, **35**, 701–2(1922).—Calcns. are made from the laws of dil. gases. The results are plotted in graphical form, convenient for fuel engineers. H. C. P. (*C. A.*)

132. Technical electroösmosis. P. H. PRAUSNITZ. *Kolloid-Z.*, **31**, 319–23 (1922).—Electroösmosis has been industrially used in the purification and partial dehydration of clays, peat, etc. Glue, gelatin, glycerol, nitrocellulose, beet sugar solns., serums and tanning solns. have been purified. The methods for *clay* purification are given in some detail. Clay in colloidal suspension may be pptd. in dense form by d. c. Emulsions may be broken down. Cf. *Ceram. Abs.*, **1** [8], 198(1922).
J. O. H. (*C. A.*)

PATENTS

133. Isolation of alumina from clay. HIROSHI TANAKA and the TOKYO KÔGYÔ SHIKENJO. Japan. 40,177, Oct. 3, 1921. Powdered clay is burned to a porous mass, mixed with concd. H_2SO_3 at low temp. and the mixt. is heated in a Pb-lined autoclave with agitation. When the reaction is completed the mixt. is cooled and filtered in the absence of air. The filtrate is heated at 100° in the absence of air to decompose $Al_2(SO_3)_3$ into Al_2O_3 and SO_2. A product of high purity is obtained. (*C. A.*)

134. Treatment of clay. W. FELDENHEIMER and W. W. PLOWMAN. Brit. 186,855, Nov. 21, 1921. Addn. to 184,271 (*C. A.*, **17**, 194). The process described in the prin-

cipal pat. is modified by using as a deflocculating agent a dil. aq. soln. contg. the pyrophosphate of an alkali base, *e. g.*, Na pyrophosphate. The clay may be subsequently recovered from its suspension by the process of flocculation described in 121,191 (*C. A.*, **13,** 647) or otherwise. Cf. *Ceram. Abs.*, **2** [3], 51(1923). (*C. A.*)

General

135. The swelling of sand upon absorption of moisture and its effect upon batch mixing. L. E. NORTON. *Pottery Gaz.*, **47,** 1371–2(1922).—2% addn. of H_2O caused an expansion in the vol. of sand of no less than 12.4% and in some cases the max. increase in vol. was reached when but 1% of H_2O was added. Hence measurement of sand by vol. cannot be considered trustworthy if a batch mixt. of accuracy is desired. In the discussion several took issue with reported increase in volume of sand upon the addn. of such small percentage of water. J. W. H.

136. Manganese dioxide produced by chemical process in California. GEORGE J. YOUNG. *Eng. Mining Jour.*, **114,** 880(1922).—Finely ground ore is digested with sulphurous acid and air. Soln. is treated with calcium nitrate. Copper originally in ore ppt. by Al. $CaSO_4$ sepd. from soln. by evapn. and filtering. Manganese nitrate dissoc. by heat: HNO_3 and MnO_2 separately recovered. The dioxide is high grade and especially adapted to demands of chem. and glass manuf. S. L. G.

137. Barytes, occurrence, mining, uses. RAYMOND B. LADOO. *Eng. Mining Jour.*, **115,** 319–24(1923). S. L. G.

138. Forms of specifications for purchasing coal. HUBB BELL. *Proc. Am. Soc. Testing Materials*, **22,** Part II, 567–79(1922). J. L. W. (*C. A.*)

139. Rational basis for coal-purchase specifications. E. B. RICKETTS. *Proc. Am. Soc. Testing Materials*, **22,** Part II, 557–66(1922).—An explanation of some of the points necessary to be considered in adopting a satisfactory specification.
J. L. W. (*C. A.*)

140. Gas producers and producer gas. VICTOR WINDETT. *Blast Furnace Steel Plant*, **11,** 55–60(1923).—A discussion of what constitutes correct practice.
J. L. W. (*C. A.*)

141. The determination of volatile matter in fuels. P. WEDGWOOD AND H. J. HODSMAN. *J. Soc. Chem. Ind.*, **41,** 372–4T(1922).—Monel metal and calorized steel crucibles were studied as substitutes for Pt in the Am. Chem. Soc. method for volatile matter. The dimensions were those of the Pt crucible. The results are consistent, but about 0.5% lower than with Pt, owing to oxidation of the crucible, less loss by entrainment, and the fact that 3 min. instead of 1 min. are required to reach 930°. Monel metal is the better; it was still good after 50 detns. E. W. T. (*C. A.*)

142. Clay in 1921. JEFFERSON MIDDLETON. U. S. Geol. Survey, *Mineral Resources of U. S., 1921*, Pt. II, 105–10(preprint No. 18, publ. Sept. 20, 1922).
E. J. C. (*C. A.*)

PATENTS

143. Vertical gas retort and producers. J. W. DRAKE. U. S. 1,444,498, Feb. 6. Two gas producers adjoin a vertical retort and a passage leads from each of the producers to a chamber common to and intervening between the retort and the producers. Another passage leads from the chamber mentioned to a chamber surrounding the vertical retort. A duplex valve is mounted between each of the producers and the chamber first mentioned. (*C. A.*)

144. Automatic governor for gas producers. G. R. MCDERMOTT. U. S. 1,444,383, Feb. 6. A blast-blower of a gas producer is steam-driven and the supply of steam for

driving the blower is automatically controlled by back pressure to maintain a uniform flow of air. (*C. A.*)

145. Apparatus for scrubbing coal gas. A. F. MESTON. U. S. 1,444,627, Feb. 6. The gas to be treated is passed in succession through an absorption chamber, a spray chamber and an elec. precipitator, arranged one above another. (*C. A.*)

146. Fire-resisting composition. C. E. WELLES. U. S. 1,436,618, Nov. 21. A fire-resisting mixt. adapted for addn. to ordinary paints is formed of ZnO 1–2 lbs., air-slaked lime 1–2 lbs., linseed oil 1 qt., H_2O 1 pint, kerosene 1 pint, "sol. glass" (30–35° Bé.) 2–4 oz. and molasses 1–2 oz. (*C. A.*)

BOOK

A Bibliography of Colloid Chemistry HARRY N. HOLMES. The National Research Council has recently issued a Colloid Bibliography in mimeographed form, by Dr. Harry N. Holmes of Oberlin College, Chairman of the National Research Council Committee on the Chemistry of Colloids, a book of 135 pages containing 1800 references on 106 topics. All the references are classified and many are accompanied by brief comment. This book may be purchased from the Washington office at $1.00.

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BULLETIN
of the
American Ceramic Society

A Monthly Publication Devoted to Proceedings
of the Society, Discussions of Plant Problems, Discussions
of Technical and Scientific Questions and
Promotion of Coöperative Research

Edited by the Secretary of the Society Assisted by Officers of the Industrial Divisions

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PRESIDENT'S PAGE

It is not too early for the members of the SOCIETY to plan their summer vacations and it is the earnest desire of the officers that consideration be given this year to the Annual Summer Meeting as a means of spending a most delightful holiday with fellow ceramists to the Detroit district. The trip last year to Canada was a splendid success and much enjoyed by all those who attended.

The trip is planned for August 8, 9, 10, 11, and will consume four days. The itinerary with full details will be mailed to you shortly. Will you not plan to attend and bring the entire family? The ladies add so much to the pleasures of a trip of this kind.

The Committee appointments have now been made and it is sincerely hoped that all Committees will continue to function during the entire year. There is a tendency to drop Committee work during the summer months and leave most of the work until fall which leaves only a short period before the Annual Meeting. Due to vacations it is sometimes hard for a Committee Chairman to get action during the summer, but it is hoped that each Chairman will outline his work for the year and get these outlines into the hands of members of the Committee so that some thought may be given to the details during the next few months. Action will be so much easier to get in the early fall if this is done. As so much more can be accomplished if the Committees can get together during the year, will not each Chairman attempt to get at least some members of his Committee to attend the Sum-

mer Meeting? More real work can be accomplished on this trip in a few days than is possible in months through correspondence.

Practically all of the Divisions are now organized and their Committees should also begin to function. It is not too early for the Committee in charge of Papers and Programs to begin solicitation for papers for the Atlantic City Meeting. It is so much easier at this time to obtain promises of papers than if the matter is left until a month or two before the Annual Meeting.

Few members realize how splendidly the SOCIETY is beginning to function as a consulting agency. It is surprising the number of requests for information, both from members and non-members, which are sent in to the Secretary's office. These requests vary from the composition of glaze to men to fill positions in ceramic plants. Fortunately our versatile General Secretary is able to give the required information in almost every case without reference to other members, but when he is not able to do so members can always be found who are willing to give the requested assistance.

EDITORIALS

PIONEERING BEYOND THE RIM[1]

EDITOR'S NOTE.—We are indebted to the Editor of *Saturday Evening Post* for permission to reprint these paragraphs taken from a most excellently written and illustrated article on the value of industrial research. The reproduction of these paragraphs here is to give emphasis to the truths in them enunciated.

The nation that leads the world in business and commerce must lead also in research. Success today depends more on mental than material equipment. The vital need of the moment in America is for an additional 10,000 highly trained scientific investigators, each of whom may be used as a teacher or nucleus of research groups. Only in such a way can we effectively remedy waste, improve government, and rapidly develop the basic art of industrial chemistry. If we let other nations excel in research we must concede to them important advantages and be content to play a minor rôle in world affairs.

We have heard much talk about preparedness. Many people call attention to the fact that the earth has been in an almost constant state of war for 10,000 years. The truth is, that active, increasing research is the very best type of preparedness, not only for national defence but for industrial peace. The uncovering of buried treasures of new knowledge is the most effective way for a people to strengthen themselves.

When a nation stops discovering new things we have the first sign of sure decay. Though progress in research in the United States has been slow, it nevertheless is clearly evident. More than 1300 American companies have laboratories and about 10,000 men and women are employed in them. Most of our corporations engaged in scientific investigative work have linked up with governmental agencies, trade and technical organizations and universities, in a systematic effort to increase the speed of actual accomplishment through an interchange of ideas.

But though we have laid the foundation for a broad campaign of national research, the effort so far made represents only the first feeble steps of an infant industry. Dozens of great corporations continue to pay $100,000 a year for legal advice and $10,000 for scientific guidance. Most of these companies are run by executives who lack the ability to keep one jump ahead of their competitors on the modern plan of inviting inspection and therefore they endeavor to cover up their incompetence by resorting to the locked door and sharp practice. Industrial secrecy has done more than all else to retard coöperative research.

Thanks to some of our progressive leaders, and especially to our trade associations, the rank and file of American manufacturers are beginning to understand what research is, how much it costs, and why it pays. They have come to know that it is a mistake to rely upon governmental agencies to carry on scientific work that is designed to better their own particular business. They have learned that coöperation in research is absolutely essential, and that it is possible to improve life and yet make a profit on the operation.

If there is anyone who does not believe in the wisdom of having business and science coöperate for their mutual advantage, then a brief study of the industrial progress throughout the world in recent years should convince him.

It has been only a comparatively short time since we commenced to manufacture cement, and yet the use of concrete made of cement, with water and aggregate, is increasing in an amazing way. The infant cement industry grew so fast that the manufacturers

[1] Floyd W. Parsons (*Saturday Evening Post*, May 5, 1923).

had very little time to give to a scientific study of their product, and the result was a succession of failures in many construction jobs where concrete was used. Then the cement people decided to go in for research, and almost immediately the new knowledge developed served to put the industry on a basis of stability that did not exist before. Experiments were carried on to show what quality of concrete is most economical in certain lines of construction. Tests were established so that everyone might determine the suitability of available aggregates. Rules were formulated for proportioning, mixing and placing the material. Experiments were completed to show the effect of changes in the proportions of materials, and of the exposure to wear and weather. For years people who mixed concrete assumed that the only materials of importance were the cement, sand and pebbles or crushed stone. A short time ago the research workers obtained revolutionary results by proportioning the water in the concrete mixes. Now we know that the amount of water used is nearly as important as the solid materials, and today the cement industry is of a single mind with respect to the value of coöperative research on a national scale.

. . . . . The up-to-date executive lays out his research under five heads: First is the research to improve his everyday methods; second, research aimed at a specific commercial object; third, pure-science research, which has no immediate industrial object in view; fourth, research applied to public service, or investigations designed to study the needs of the consumer, and to analyze the fields of use of a manufactured product; fifth, there is research in standardization of procedures and products.

The sooner we all recognize the earning power of research, the sooner we shall get on a highway leading to a state of prosperity that will be far more satisfactory and permanent than any we have ever yet enjoyed. One manufacturer was wasting $100,000 a year on raw materials purchased without regard to moisture content. Now he has learned the importance of the accurate control of moisture. On one railroad the boiler tubes of switch engines had an average life of seven months. It cost $1200 to replace a set of tubes. Research has extended the life of the tubes to thirty-one months, and the company has 1600 locomotives. A large gas company uses 3500 barrels of gas oil a day. The management recently spent $350,000 in developing a cracking process all their own. As a result they now get a 27 per cent yield of gasoline out of each barrel of oil. The remaining oil is 7 per cent better for their purpose than it was before the gasoline was removed. As a result of this research the company is saving $1.24 on each barrel of oil, or $4,340 daily. Here is a scientific achievement that pays 100 per cent interest every eighty days.

A great many people are coming to believe that it is safer and better to judge the future of a corporation or an industry by its fixed attitude toward research than by its working capital, its past earning power or its fixed assets. Scientific investigation is the only wise and economical way to stop waste and indefinitely postpone the exhaustion of our natural resources.

FRANK P. JUDGE'S STATEMENTS OF VALUE OF INDUSTRIAL RESEARCH

At the annual meeting of the United States Potters' Association held in New York City in April, Frank P. Judge, Jr., president of the Association was among the prominent speakers for the occasion. A part of his address of especial interest to the members of the AMERICAN CERAMIC SOCIETY is reprinted from the *Evening Review*, of East Liverpool, Ohio.

"For years our forefathers toiled along as best they could contenting themselves with the results they obtained under adverse manufacturing conditions but the progress of time and the demand from the consumer made it imperative for us to give thought and attention to the improvement of our product. The full significance of this did not dawn upon us until importations of foreign dinner ware were curtailed by reason of the recent World War which practically put all manufacturing at a standstill, exclusive of such as was necessary to the conduct of the war and to provide the actual necessities of the people. The American potter was not slow to realize that his opportunity was at hand and the past few years have seen many changes in our manufacturing processes. We are proud of the fact that our products today are far superior in body, glaze, art and design than they were a few years ago.

"We must not stop with our accomplishments of today but we should exert every effort to continue the perfection of our wares so that we shall eventually be able to supply all the demands of our home consumption and, in addition, develop an export trade. To do this we cannot follow along the same lines as we did years ago encountering difficulties and not knowing how to overcome them other than to work all angles on the problem until it was solved—consequently we were still in the dark as to the cause of the trouble.

"It is a well known fact that the progressive industries of today do not rely upon past experience handed down from generation to generation but are solving their manufacturing problems in their research laboratories with technically trained men, spending their time studying ways and means to reduce losses in the course of manufacture, better and more economic methods, testing materials and lastly, but not least, the betterment of the product. A few of our largest potteries are now maintaining their own research laboratories and look upon them as one of their most valuable assets. A smaller pottery needs the service of the technical man just as much as the large one but the needs of the small pottery hardly justify the maintenance of a research department. To take care of the small potteries it is suggested that a research laboratory be established at a central point (in the name of the United States Potters' Association) which would be in charge of a Ceramic Engineer whose service would be available to any member of our association at any time, the member paying for the individual service he would receive. When not engaged in doing work for an individual factory the ceramic engineer could be conducting experiments, studying raw materials, methods of firing, fuels, etc. It is my sincere hope that before this meeting adjourns some action will have been taken on this matter. Our industry is expanding and the work of our Association should expand with it.

"At the last annual meeting a new committee was created. It is known as our research committee and in the short space of time it has been functioning, much valuable information has been furnished our members. The outstanding feature of the work of this committee during the past year was to interest the United States Bureau of Standards in working out some of our problems. On October 27th, 1922 a fellowship was established at the Bureau to work on one of our greatest problems—that of crazing. A ceramist is now making a systematic study of this and we are looking forward to receiving an interesting report from this fellowship later on in our program. In addition to working on the crazing question the Bureau is also experimenting with sagger clays to determine which clay or combination of clays will give us a sagger better than what we are now using.

"Considerable assistance can be given to the Research Committee by the kiln and fuel also the machinery committees by providing confidential and reliable reports on such subjects that would come under the work of the respective committees.

"Each succeeding year is finding a decided improvement in the artistic side of our

business and before very many more years pass into history the evil of imitating shapes, decorations, etc., will be stamped out.

"Each factory should put individuality into its product and the sooner we come to the realization of this just that much sooner will the keen competition of the past be eliminated. To stimulate activity along the line of originality in shapes and decorations a prize could be given each year by the United States Potters' Association to the individual suggesting the best designs for dinner services and to the decorator or artist offering the best suggestions for decoration.

"We might not feel the necessity of serious consideration of this subject at the present time but we must not forget that there is a day coming when everything is not as favorable as it is now and that will be the time when the product of fine quality, originality in shape and decoration will not need to fear competition, either foreign or domestic.

"You supply dealers can be of valuable assistance in carrying on this work. The best materials obtainable should be brought to our attention and the decalcomania dealers could assist by refusing to make decorations which they know are already on the market and by keeping their lines free of decorations that are similar in design and appearances. This would not benefit the potter alone, but should materially benefit the decalcomania manufacturers. I cannot urge upon you too strongly to give serious thought to this side of our business. Let each one of us leave this meeting with a firm resolve to make our respective products original and recognizable by their individuality."

SCIENTIFIC RESEARCH ENTERS NEW ERA

Activities of Engineer Organizations

Scientific research, affording new channels for the aspirations of the engineer, is entering upon a new era both here and abroad. Following the $500,000 gift of Ambrose Swasey of Cleveland, making possible the organization of Engineering Foundation, comes news from London that Sir Alfred Yarrow has given the same amount to the Royal Society for the same purpose.

The philanthropy of Sir Alfred, who is an honorary member of the American Society of Mechanical Engineers, is characterized as another step toward the identity of effort which engineers and men of science are striving to accomplish throughout the Anglo-Saxon world.

"I should like to record my firm conviction that a patriotic citizen cannot give money, or leave it at his death, to better advantage than towards the development of science, upon which the industrial success of the country so largely depends," said Sir Alfred in his deed of gift.

PAPERS AND DISCUSSIONS

REPORT OF COMMITTEE ON STANDARDS[1]

By Walter A. Hull[2]

The Standards Committee wishes to present to the Board of Trustees the accompanying specification for Limestone, Quicklime and Hydrated Lime[3] for use in the manufacture of glass. This specification was prepared by Mr. A. E. Williams for the Interdepartmental Conference on Chemical Lime, which is a conference made up of representatives of interested governmental departments. It has been approved by the Interdepartmental Conference and by the Standards Committee of the Glass Division of the American Ceramic Society and it should be stated in this connection that members of the Glass Division were consulted freely during the preparation of the specification. Subsequent to its approval by the Standards Committee of the Glass Division, slight revisions were made. These revisions were approved by the Interdepartmental Conference. The revised specification was then submitted to letter ballot of the Standards Committee of the American Ceramic Society. This Committee now recommends that the specification be adopted as a Standard of the Society.

Since the various Divisions of the Ceramic Society have been organized, with Standards Committees of their own, the General Committee on Standards has automatically become, in large measure, a coördinating committee. The work of developing tests and preparing specifications for materials which are used or produced by members of one Division only, properly belongs to the Standards Committee of that Division. The duty of the General Committee on Standards in such a case is to give the specification a final inspection before recommending that the Society adopt it as a standard. One of the objects of this inspection by the Standards Committee is to make sure that there is no conflict with and no unnecessary duplication of the specifications submitted by other Divisions. In the case of a material or product of interest to more than one Division, it is a proper function of the General Committee on Standards to act as a clearing house or coördinating agency.

Until within the last couple of years the work of the American Ceramic Society on standards has been almost wholly along the line of methods of testing clays and one or two types of ceramic products. In other words, the standards which have been given a definite status by the Society are almost wholly standard methods for laboratory workers. Very recently, say within the last two or three years, there has been more of a tendency to try to devise suitable specifications for use in the purchase of materials such as feldspar, flint, whiting and limestone which are purchased in quantity by members of the Society. Thus we find specifications pro-

[1] See "Tentative Specifications for Glass House Refractories," *Bull Amer. Ceram. Soc.*, **2** [3], 29 (1923).

[2] Chairman, Committee on Standards. [3] See p. 170, *This Bulletin*.

posed for refractories for glass tanks; feldspar, flint and whiting for the whiteware industry; and limestone, quicklime and hydrated lime for glass manufacture. One of these proposed specifications is now definitely recommended for adoption as a Standard of the SOCIETY. It is expected that the Whitewares Division may approve one of the others at the 1923 Annual Meeting so that it can be considered by the General Standards Committee for presentation to the SOCIETY at the 1924 Annual Meeting. It is hoped that the work already done on specifications for feldspar may be materially supplemented by the coming colloquium, and that satisfactory specifications for feldspar for certain specific purposes may be added to the Standards of the SOCIETY within reasonable time.

There is an opportunity for practically every Division to work on specifications for materials purchased by members of the Division. It is predicted that as one after another of the Standards Committees of the different Divisions begin to give active attention to this work, it will be found that the Divisional Standards Committees need strengthening by adding active, representative members to the personnel of these Committees. In order that the SOCIETY may do constructive work in the preparation of specifications, each Divisional Standards Committee must be so representative that a specification that is put up to a Division for action will represent the best thought obtainable in the Division. In order to work most effectively, it would be necessary for the Divisional Standards Committee to assemble in committee meetings at intervals and work out questions pertaining to specifications. Whenever the group of manufacturers represented in a given Division gets to be "sold" on the value of specifications for the materials purchased or the products sold, it will become possible to secure attendance at such meetings. In the meantime, it is almost a primary essential for every Divisional Standards Committee which is going to function to have a chairman or secretary who can obtain stenographic assistance.

It is believed that suitable specifications for use in the purchase of materials alone will result in a large saving in costs and reduction in factory troubles to members of the SOCIETY. It may not take long for the first specifications put in force to show results, and results will give the movement an impetus quicker than anything else.

THE ANALYSIS OF HIGH ALUMINA PRODUCTS[1]

BY C. A. UNDERWOOD

Introduction

With the recent introduction of refractory products having an alumina content from 60 to 85%, it may prove desirable to discuss the method of

[1] Read before the Refractories Division, Pittsburgh Meeting, February, 1923.

analysis employed with such refractories. In this class are included diaspore, bauxite, spinel and the various products made from these materials.

Considerable detail is given in order that the operator may proceed without the trouble of devising the technic and to help him over the pit falls.

Ordinary clays can be thoroughly decomposed by fusion with sodium carbonate. For diaspore and similar materials either sodium or potassium pyrosulphate must be used. The burnt products can be fused directly whereas the raw material must be calcined to drive off the combined water. Otherwise the diaspore will float on the fusion and crawl up and over the wall of the crucible, causing loss of part of the sample and preventing the remainder from being acted upon by the pyrosulphate. This makes it advisable to determine the loss on ignition first.

"Loss on Ignition"

Exactly one gram of the sample, which has been dried at 105°C for one hour and cooled in a desiccator, is weighed into either a platinum or porcelain crucible and heated for 30 minutes at not less than 1000°C. The ignition may be conducted in an electric furnace or over a good blast, care being taken that all samples receive the same treatment. Different operators may obtain slightly different results owing to differences in the temperature of their blasts. Hence the "loss on ignition" is a somewhat variable determination.[1] Owing to decrepitation it is necessary in some cases to raise the heat gradually.

Solution of the Sample

The sample on which the ignition loss has been determined is transferred from the crucible to an agate mortar and pulverized. An amount corresponding to 0.5000 of the original (crude) sample is then weighed out and mixed with 10 to 15 grams of fused potassium pyrosulphate. To illustrate: Assume the loss on ignition to be 13.50%. Then $\frac{100.00-13.50}{100} \times 0.5000 =$ .4325 gram, the amount necessary to weigh out.

This procedure has two advantages: first, there is time saved, and secondly, the size of the alumina precipitate will be smaller.

The fusion requires about three hours, beginning with a very low flame and gradually increasing until the sample is thoroughly decomposed; a condition which exists when flocculent silica is seen in the melt. If there is any undecomposed material adhering to the wall of the crucible, it can be brought into solution by carefully removing the cover and tilting the crucible so that the melt may act upon it.

[1] W. F. Hillebrand, "The Analysis of Silicate and Carbonate Rocks," U. S. Geol. Surv., *Bull.* **422**, p. 231.

When the fusion has cooled the button is removed from the crucible and the crucible and cover placed in a 400-cc. beaker containing 150 cc. of dilute hydrochloric acid (1−1). Heat gently on the hot plate until crucible and cover are clean. Remove, add the button to this solution and continue to heat until solution takes place. The solution will finally become clear, only the silica remaining undissolved.

Silica

Transfer to a porcelain evaporating dish and evaporate as nearly to dryness as possible. It is impossible to remove the last traces of acid on the water bath, but by occasionally breaking up the crust that forms, very nearly all can be driven off. Dryness is accomplished by supporting the evaporating dish about two inches above the top of a hot plate, care being taken not to heat too rapidly so that spattering takes place. By this means all acid can be removed and the silica dehydrated.

Fifty cc. of dilute hydrochloric acid and 150 cc. of hot water are now added and heat applied until all except the silica is in solution. Filter through a 11 cm. filter paper, receiving the filtrate in a 400-cc. beaker. The silica is washed six times with cold water and six times with hot water, after which it is ignited and weighed in a platinum crucible.

Moisten the impure silica with a few drops of water; add two drops of concentrated sulphuric acid and 10 to 15 cc. of hydrofluoric acid. Evaporate (do not boil) until the sulphuric acid has been expelled, ignite and weigh. The difference in the two weights represents the true silica.

If desirable, the filtrate can be again evaporated to dryness, but this is unnecessary for ordinary work.

Alumina, Iron Oxide, and Titania

The residue from the hydrofluoric acid evaporation usually amounts to 5 milligrams or less and consists of alumina, iron oxide, and titania. It is fused with one or two grams of potassium pyrosulphate and when cold is dissolved in the filtrate obtained from the silica separation. The solution now contains all the constituents to be determined except the alkalies. It is transferred to a 500-cc. graduated flask and filled to the mark. Mix thoroughly and pipette 200 cc. into a 400-cc. beaker.

Pass hydrogen sulphide through the solution for ten minutes or until all the platinum is precipitated. Heat to boiling to coagulate. Filter into a 600-cc. beaker and bring to boil to expel the hydrogen sulphide. Add bromine water to oxidize the iron, and continue to boil until the excess bromine has been driven off. Dilute to 450 cc.

There is an appreciable error caused by the solution of platinum during the pyrosulphate fusion. This must be removed; otherwise the alumina

will be high. It takes considerable time, however, to throw out the platinum with hydrogen sulphide and then reoxidize. For general work, this can be avoided by weighing the platinum crucible before and after the fusion. The loss in weight is then deducted from the weight of the alumina precipitate.

After expelling the bromine, the alumina, iron and titanium are precipitated with ammonia, using rosalic acid as an indicator. It is best to add the last drops of ammonia from a pipette so that the color change can be followed closely. Allow the precipitate to settle and filter through a strong 12.5-cm. filter. Rinse the beaker with hot dilute ammonium nitrate solution to get all on the filter and then wash five times, breaking up the precipitate in order to wash it thoroughly.

Save the filtrate and redissolve the precipitate into the original beaker with hot dilute hydrochloric acid (1−1). Dilute to 450 cc. and precipitate as before. On filtering scrub the beaker clean and wash five times with the ammonium nitrate solution. Save the filtrate.

The alumina precipitation is the most difficult part of this analysis and unless every precaution is exercised, good results cannot be obtained.[1] The precipitate should not be washed with pure water but either with dilute ammonium nitrate or chloride. Also the volume of the solution should not be less than specified. The large amount of fixed alkalies present are adsorbed by the alumina precipitate and are difficult to remove. Pure ammonia, as recommended under "Reagents," is likewise necessary since any error introduced in this way is multiplied many times in the result.

After the alumina precipitate has drained for a short time, it is placed in a platinum crucible of sufficient size and dried; care being taken not to lose any by spattering. It is then ignited, blasted for twenty minutes, cooled in a desiccator and weighed with cover on. A second blasting for ten minutes will show if constant weight has been obtained.

Iron

The combined oxides of aluminum, iron and titanium are fused with ten grams of fused potassium pyrosulphate, exercising all the precautions necessary in pyrosulphate fusions. When all has been dissolved allow the fusion to cool. Remove the button to a watch glass by gently tapping and place the crucible and cover in a 150-cc. beaker. Add 75 cc. of water and 10 cc. of conc. sulphuric acid. Heat gently until the crucible and cover are clean. Remove and add the button to this solution. Continue to heat gently until the fusion is completely dissolved and transfer the solution to a 500-cc. Erlenmeyer flask.

[1] William Blum, "The Determination of Alumina as Oxide," Bur. Stand., *Sci. Paper*, No. **286**.

The Erlenmeyer flask is supported at a convenient angle and hydrogen sulphide passed through until the platinum sulphide is all precipitated. Bring to boil and filter into another Erlenmeyer flask of the same size. Again pass hydrogen sulphide through the solution until the solution becomes cloudy owing to the presence of free sulphur. Complete reduction can be determined by testing a drop of the solution with potassium sulphocyanate.

The flask is now removed to the hot plate and supplied with a Bunsen valve. On boiling gently the solution will first become clear and finally all traces of hydrogen sulphide will be expelled. This point is ascertained by moistening a piece of filter paper with lead acetate solution and allowing the escaping steam to play upon it. When the filter paper fails to turn black, all hydrogen sulphide has been driven off.

The Bunsen valve is removed and the iron titrated with $N/25$ potassium permanganate. The permanganate is added slowly while the solution is given a rotary motion. The end-point is reached when a pink flash is obtained throughout the whole solution. Two drops excess will color the solution for several seconds.

Titanium

After the titration of iron the solution is transferred to a 250 cc. graduated flask. When cool, 5 to 10 cc. of hydrogen peroxide free from fluorine are added and the flask filled to the mark. Pipette 50 cc. of this solution into a Nessler tube.

Pipette 10 cc. of a standard titania solution containing approximately 0.001 gram per cc. into a 100-cc. graduated flask. Add 5 to 10 cc. of hydrogen peroxide and fill to the mark. After mixing add 10 cc. to a second Nessler tube and add water from a burette until the color matches that of the test solution. From the results calculate the percentage of TiO_2.

Large amounts of iron and alkali sulphates interfere with this determination. In this class of products, however, only a small amount of iron is found and there is sufficient sulphuric acid present to prevent interference by the alkali sulphate.

In comparing the colors it is best to use some form of colorimeter. Otherwise the shadows produced make the comparison difficult.

Alumina

By deducting the iron and the titania from the total alumina precipitate ($Al_2O_3 + Fe_2O_3 + TiO_2$) the percentage of alumina is found.

Calcium Oxide

The two filtrates from the alumina, iron and titania precipitations are combined and evaporated to about 400 cc. Bring the solution to boil

and add 25 cc. of saturated ammonium oxalate solution and a few cc. of ammonia. After continuing the boiling for one or two minutes longer, set the solution back on the hot plate so that it will remain hot but not boil. Evaporate in this way to a volume of approximately 250 cc. Remove from the hot plate and allow to stand over night. Filter, wash the precipitate of calcium oxalate two or three times. Save the filtrate. Redissolve the precipitate into the original beaker with dilute hydrochloric acid (1−1).

Dilute the calcium solution to 250 cc. Heat to boiling, add a few cc. of the ammonium oxalate solution and precipitate with ammonia. Heat again to boiling and allow the precipitate to settle for two hours, keeping hot. At the end of this time, filter off the precipitate. Wash six times with hot water.

To the beaker used for the precipitation, add 150 cc. of water and 6 cc. of concentrated sulphuric acid. Heat to about 70°C and introduce the filter paper containing the precipitate of calcium oxalate. Titrate with $N/25$ potassium permanganate, allowing for the effect of the filter paper. Calculate the percentage of CaO.

Magnesia

Combine the filtrates from the calcium oxalate precipitations and evaporate to about 400 cc. Dissolve one gram of sodium-ammonium phosphate in a little warm water and add to the solution. Next add 100 cc. of ammonia, and allow to stand at least twelve hours.

At the end of this time filter off the precipitate, rejecting the filtrate. Redissolve the precipitate into the original beaker with dilute nitric acid (1−5). Dilute to 150 cc. and again precipitate with 5 cc. of the sodium-ammonium phosphate solution and 50 cc. of ammonia. Allow the precipitate to stand four or five hours; filter, and wash well with cold water to which 5% ammonia has been added.

The precipitate can be collected either in a Gooch or on filter paper. Where filter paper is used it should be burnt off very slowly. The electric furnace is ideal for igniting magnesia.

Finally weigh the precipitate as $Mg_2P_2O_7$ and multiply the weight by 0.3621 to reduce it to MgO.

The addition of 50 cc. of alcohol will facilitate the precipitation of the magnesium-ammonium phosphate.

Potash and Soda

The alkalies are usually determined by the J. Lawrence Smith method. The description of this method given by Washington[1] may well be consulted where detail and great accuracy are desired.

[1] H. S. Washington, "The Chemical Analysis of Rocks," 191 (1919).

Pulverize about one gram of the sample in an agate mortar until it is reduced to an extremely fine powder. Weigh out 0.5000 gram and place in the clean agate mortar. To this add one-half gram of ammonium chloride and mix thoroughly with the aid of the pestle.

Approximately 4 grams of calcium carbonate are now weighed out and added to the mixture in two or three portions, care being taken to thoroughly mix the three ingredients. It is desirable that each particle of the sample be in contact with a particle of calcium carbonate, and a particle of ammonium chloride.

A small amount of calcium carbonate is now tamped into the bottom of a platinum crucible; the mixture is then added and covered with an additional portion of the carbonate. The crucible is covered and warmed gently for 15 minutes after which the heat is increased until only the lower half of the crucible is a dull red. Continue to heat in this way for 45 minutes. The heat is then removed and the crucible allowed to cool.

To a platinum or porcelain basin add 50 to 75 cc. of water and cover with a watch glass. When the fusion has cooled introduce the crucible and contents and also the cover. Allow to stand a short time and remove the crucible and cover. The melt is now broken up with the acid of the agate pestle and the liquid brought to boil. Decant into a 600-cc. beaker. Break up the residue, add 100 cc. more of water and bring to boil again. Decant as before. This operation is repeated the third time except that the contents of the basin are transferred entirely to the filter. The residue is then washed several times with hot water.

To the filtrate, which should have a volume of 300–400 cc., add 3 or 4 cc. of ammonia and bring to boil. In the meantime about 2 grams of ammonium carbonate are dissolved in cold water, and added until complete precipitation takes place. Keep hot and allow the precipitate of calcium carbonate to settle. Filter into two six-inch porcelain evaporating dishes and evaporate nearly to dryness. Transfer both solutions to a platinum basin or a three-inch evaporating dish and continue the evaporation to dryness.

The next operation is to expel the ammonium salts by gentle ignition with a moving flame. Finally bring the basin to dull redness to remove the last traces of salts, care being taken to avoid heating the alkalies above their melting points. Allow the basin to cool and add 25–30 cc. of water. Tip the basin to insure solution of the soluble salts and add two drops of ammonium oxalate. Evaporate again almost to dryness. Take up with 5–10 cc. of water and filter into a platinum crucible of 35-cc. capacity. Rinse the basin and wash six times with small amounts of hot water. Add two drops of dilute hydrochloric acid and evaporate the solution to dryness. Ignite gently to expel the ammonium salts, care being taken to avoid decrepitation and volatilization of the alkalies. When the crucible has cooled take up again in 5–10 cc. of warm water and again

filter. This time the filtrate is received in a weighed platinum crucible of 35 cc. capacity. Evaporate, ignite gently, and weigh as NaCl + KCl.

Separation of Potash[1]

The chlorides as obtained above are dissolved in the crucible with about 5 cc. of water and a definite amount of chloroplatinic acid added. If the solution of chloroplatinic acid contains 0.05 gram of platinum per cc., the result will be the number of cubic centimeters of chloroplatinic acid to be added. In order to be certain that an excess of the platinum solution has been used it is well to add a few drops excess. In this class of work 1 cc. will be sufficient in practically all cases.

The crucible is now placed on the water bath and allowed to simmer. If the precipitated potassium platini-chloride does not dissolve when the liquid is warm, a few cc. of water are added to effect its solution. Evaporate until the liquid becomes syrupy and solidifies on cooling. Allow the evaporation to cool and fill the crucible half full with alcohol of 0.86 specific gravity and allow to soak.

When all but the precipitated platini-chloride has gone into solution, the solution is decanted through a Gooch filter. Wash several times by decantation using the specified alcohol and finally transfer the precipitate to the filter. Continue the washing several times. Remove to an air bath at 130° to remove all traces of water. When this has been accomplished remove to a desiccator and when cool weigh as K_2PtCl_6.

Multiply the weight of potassium platini-chloride by 0.1938 to reduce to K_2O. Also multiply the weight of the platini-chloride by 0.307 to reduce it to KCl. This result deducted from the weight of the total chlorides gives the weight of the NaCl, which in turn is multiplied by 0.5308 to reduce it to Na_2O.

Summation of Results

There are on record, analyses which total 102 to 103%. These are obviously much too high and as a rule the error is not due to high results on all the constituents. It is more likely attributable to one determination and that determination is alumina.

Owing to the nature of the alumina precipitate, it is capable of adsorbing large amounts of fixed alkalies. Hence, great care must be exercised in washing it properly. Secondly impure ammonia, and failure to remove the platinum taken up during the fusion will add still more to this constituent.

An analyses which totals above 100% is usually better than one which totals below. There are always small amounts of impurities in the re-

[1] H. S. Washington, *op. cit.*, 202.

agents and considerable dust is collected before the analysis is finished. There are also minus errors which may occur but they are usually overbalanced by the plus ones. In the course of a great many analyses on products running from 60 to 85% Al_2O_3, it has been found that the summation of the constituents given will be between 100% and 100.50%. It should be emphasized, however, that these results can be obtained only by exercising the necessary precautions. Where there is a great amount of work to be done and where speed is an important consideration the allowable limit might be extended to 101%.

Solutions Required

Acids.—The concentrated acids used have specific gravities approximately as follows:

Hydrochloric Acid	1.20
Sulphuric Acid	1.84
Nitric Acid	1.42

Ammonium Carbonate.—Make up as needed by dissolving 1 to 2 grams in cold water.

Ammonium Hydroxide.—The concentrated ammonia water of 0.92 specific gravity is used. It should be free from carbonates and should not be kept in glass bottles. To purify, redistil over lime and store in ceresine bottles or in the regular five-pint acid bottles which have been coated inside with ceresine. If ammonium carbonate is the only impurity present, the ammonia water can be boiled to decompose the carbonate.

Ammonium Nitrate.—Neutralize 20 cc. of concentrated HNO_3 with ammonia until the solution is just alkaline to rosalic acid. Dilute to 1 liter.

Ammonium Oxalate.—It is best to recrystallize this after filtering to free from calcium oxalate. Dissolve 1 gram in 50 cc. of water when needed.

Chloroplatinic Acid.—Of that containing about 37 per cent platinum, 10 grams are dissolved in 50 cc. of cold water. Filter through a small filter into a reagent bottle and make up to 75 cc.

Hydrogen Peroxide.—Merck's "Superoxal" is used.

Potassium Permanganate.—Make up a normal solution by dissolving 31.6 grams in 1 liter of water. Dilute this to approximately 25th normal. Allow to stand at least one week and standardize with sodium oxalate prepared for such work by the U. S. Bureau of Standards.

Titanium Standard Solution.—Either potassium titanofluoride (K_2TiF_6) or titanium oxide (TiO_2) may be used. To prepare with K_2TiF_6, the salt is heated one hour at 150°C to drive off moisture. To 1.5 grams in a platinum crucible add 5 grams of sulphuric acid (1−1). Evaporate until fumes of sulphur trioxide are given off strongly but do not take to

dryness. Repeat four or five times. When cool add 5 cc. of sulphuric acid and cautiously dilute with water. Add enough more sulphuric acid so that there will be at least 5 per cent of the final volume. Allow to cool and dilute to the mark in a 500-cc. graduated flask.

Mix the solution well and pipette off 50 cc. and dilute with water. Bring to boil and precipitate with ammonia water. Filter, wash well, ignite and weigh as TiO_2. Fuse the TiO_2 with potassium pyrosulphate, dissolve the melt, and determine the Fe_2O_3 present by potassium permanganate after reduction with hydrogen sulphide. Deduct this from the TiO_2.

The titania solution if made up as directed will contain approximately 0.001 gram TiO_2 per cc.

If TiO_2 is used instead of K_2TiF_6 0.5 gram is taken. It is either fused with potassium pyrosulphate or evaporated with a mixture of hydrofluoric and sulphuric (1−1) acids. Finally evaporate with sulphuric acid (1−1) several times and make up to 500 cc. as described above.

AMERICAN REFRACTORIES CO.
JOLIET, ILLINOIS

TESTING BARIUM CARBONATE FOR USE IN TERRA COTTA BODIES

BY W. L. HOWAT AND G. A. WILLIAMS

ABSTRACT

The value of barium carbonate for neutralizing soluble salts in a terra cotta body depends upon its activity when in contact with soluble salts. An activity test is given.

The value of barium carbonate for use in a terra cotta body to neutralize the soluble salts depends upon its activity when in contact with these soluble salts. Since the activity of a given sample of barium carbonate cannot be judged by its purity, or solubility in water or dilute hydrochloric acid, the following simple test has been adopted for this purpose.

Taking magnesium sulphate as a typical soluble salt the test is as follows:

Weigh out 2 grams of the barium carbonate sample and place in 100 cc. of a 10% solution of magnesium sulphate. Allow to stand 1 hour at 70°F (21°C) stirring at 10-minute intervals with a glass rod.

Filter and wash with warm water until no white precipitate shows when tested with barium chloride. Wash precipitate consisting of barium sulphate and barium carbonate which has remained unchanged into a beaker and treat with dilute hydrochloric acid. Collect the barium sulphate now remaining by filtering and washing with warm water until the filtrate is free of barium chloride as shown by testing with a drop of sulphuric acid.

Ignite and weigh. Correct this weight by subtracting the weight of the barium carbonate sample which is insoluble in dilute hydrochloric acid.

Convert weight of barium sulphate into terms of barium carbonate ($BaSO_4$: $BaCO_3$ = 233:197), then this weight divided by weight of sample of barium carbonate taken, times 100 equals per cent of barium carbonate which has reacted with the magnesium sulphate.

A modification of this test might also be used with equally satisfactory results, but since the per cent of barium carbonate reacting in such a test depends upon (1) the concentration of the soluble sulphate salt used, (2) the kind of soluble sulphate used, (3) the temperature, and (4) the time, it is obvious that for purposes of comparing different samples of barium carbonate over a period of time, the test must be carried out on a standard procedure.

Results to show the magnitude of the variation from these different causes are as follows, with a given sample of barium carbonate used for all tests:

Test no.		Per cent of barium carbonate reacting
1	Regular magnesium sulphate test as given	25.6%
2	Using double strength magnesium sulphate	42.5%
3	Using an equivalent amount of sodium sulphate (10.9 grams of $Na_2SO_47H_2O$ instead of 10 grams of $MgSO_47H_2O$)	73.5%
4	Using regular 10% solution of magnesium sulphate but standing for 1 hr. at 100°C instead of 21°C	78.3%
5	Regular test but standing 5 hrs. instead of 1 hr.	33.3%

It is evident from these results that in the body the longer the body is aged and the warmer the temperature, the more effective the barium carbonate will be in reacting with soluble sulphates in the body.

Effect of Fineness of Barium Carbonate

To determine whether the fineness of the barium carbonate had any effect on the per cent reacting with magnesium sulphate, the regular test was run on Sample A, as received, and after grinding 8 hrs. dried in a small jar mill. A sieving test was made before and after grinding. Regular magnesium sulphate test and sieving test was also made on a different lot of barium carbonate—Sample B.

Results	Sample "A" as received	Sample "A" ground 8 hrs.	Sample "B" as received
On 60-mesh	2.29%	0.10%	1.84%
On 100-mesh	1.16	0.62	0.60
On 120-mesh	1.86	2.51	0.26
On 150-mesh	1.39	1.55	0.79
On 200-mesh	1.83	2.92	0.90
Pan	91.47	92.30	95.61
Per cent reacting with magnesium sulphate	29.0 %	32.8 %	27.4 %

We concluded then, that while grinding a sample of barium carbonate finer would increase its activity, a sieving test comparison between two different samples would not show which was the more active. It is probable that the degree of fineness of the 90% or more through 200-mesh sieve which an ordinary sieving test will not classify has more effect on activity than the size of the 10% or less above 200-mesh.

The following are some typical figures obtained on various samples of barium carbonate

Sample no.	Insoluble in dilute HCl	Per cent reacting with $MgSO_4$
1	3.30%	31.5%
2	2.60	33.5
3	.0	31.8
4	.0	33.3
5	2.3	26.8
6	0.95	27.4
7	0.65	29.2
8	1.68	25.1
9	2.60	34.6
10	2.56	34.5
11	2.30	22.8
12	3.72	13.7
13	10.10	16.0
14	98.30	..

Below 25% reaction in the magnesium sulphate test makes the value of a sample of barium carbonate doubtful.

ATLANTIC TERRA COTTA CO.
PERTH AMBOY, N. J.

PROPOSED TENTATIVE FELDSPAR SPECIFICATIONS[1]

Since the last Annual Meeting, 1922, the Committee has been in correspondence with several producers and large consumers of feldspar.

The consumers are a unit as regards specifying the characteristics of the feldspar they purchase. As might be expected the producers see many difficulties in the way. However great and real these difficulties are, they must be surmounted to the end that the industries which give to feldspar its value may enjoy a greater measure of freedom from uncertainty and consequent loss.

Specifications for commercial feldspar and flint by A. W. Watts,[2] have assisted us all, as well as the thorough work published as Bulletin 53, of the Bureau of Mines 1913, on the "Mining and Treatment of Feldspar and Kaolin."

[1] The Discussion accompanying these specifications which took place at the Whiteware Division Meeting, Pittsburgh, will appear in an early issue of the *Bulletin*.

[2] *Jour. Amer. Ceram. Soc.*, **3** [9], 722 (1920).

It has become the practice of certain manufacturers to use more than one kind of feldspar and ground to various degrees of fineness. Feldspar millers are now grinding finer than was the common practice of even two years ago. In this connection a series of valuable suggestions have been received from Mr. G. E. Sladek calling attention to the fact that at the present time feldspars in use are of definitely different composition and definitely different grinding characteristics.

Specifications for Commercial Feldspar for Use in the Manufacture of Whiteware

In view of the above it is suggested that Prof. Watts' specifications be amended as follows:

1. The Sample.—In sampling car-load lots, equal amounts should be taken from at least five different points in the car, no two samples being taken within five feet of each other. In sampling from a bin, five separate samples shall be taken from different portions of the bin and not more than two from the same level. The total sample shall not be less than ten pounds.

The samples shall be thoroughly mixed on a smooth surface, divided in halves, one-half spread evenly over the other half. Repeat this operation five times. The mixed sample shall then be quartered and two quarters not adjoining rejected. The remaining quarters shall be mixed as described above, five times, quartered as before and two quarters rejected. The remaining sample shall weigh more than 2.2 pounds (1 kilo.) and shall be placed in a tight receptacle, marked with an identifying number or with the name of the material, car or bin number and data on which the sample was taken.

CHEMICAL COMPOSITION

Grade	K_2O%	Na_2O%	CaO.MgO%
	above	below	not above
A	10	3.6	0.75
B	9	3.2	1.00
C	7.8	2.8	1.00
	not above	not below	
D	3.0	7.0	1.00

Physical Properties and Tests

1. Color and Specking.—Bearing in mind the variety of wares in which feldspar is used and the various standards as to color and specking, potters find it necessary to establish; it is considered desirable to leave this matter open to agreement between vendor and vendee.

2a. Fineness of Grain.—One hundred grams of the sample, after being dried to constant weight at 105°C, shall be tested for fineness of grain according to the process set forth in paragraph 2b and the residues on the various sieves shall not exceed the maxima as set forth in the following table:

Screen no.	100	140	200	270	325	Total residue
Grade 1	0.25	0.5	1.25	2.0	5.0	9%
Grade 2	0.50	1.0	2.5	4.0	6.0	14%
Grade 3	0.75	1.25	3.75	5.0	8.0	18.75%

For the screen analysis the Standard Screen Scale sieves are used the openings increasing in the ratio of the fourth root of 2 or 1.189 as recommended in *Year Book*.[1] All percentages are made on the dry basis.

2b. Method of Making the Fineness Test.—The 100 grams of dry sample shall be transferred to the sieve and over a sieve pan which fits closely enough to prevent loss by slopping. The pan shall contain sufficient water to reach within not less than $^3/_4$ inch (20 mm.) or more than $1^1/_4$ inch (31 mm.) from the pan. The sieve and pan shall be vibrated or shaken in such a manner that water in the pan is splashed on the screen from below so as to wash the powder about and cause the material that can pass through the sieve to pass into the pan below. This treatment shall be continued until no more material can be removed.

The residue and sides of the sieve shall then be thoroughly washed with water by means of a laboratory wash bottle.

2c. The Washing Process.—In the washing process a fine brush may be used to break down such small aggregates as refuse to break up by washing alone.

The order of the sieves shall be as follows: Wash the sample on the 325-mesh sieve to remove all fines, as this facilitates an accurate classification of the coarse material. The material passing this sieve may be concentrated by evaporation to dryness and weighed, or may be immediately thrown away and its amount determined by difference. The residue on the 325-mesh sieve is transferred to the 100-mesh and washed as described above. The material on the sieve is dried and weighed; the material passing the 100-mesh sieve is transferred to the 140-mesh sieve and washed and this process continued to the 200, 270 and 375 in order, the residues on each being dried and weighed.

Note: In the water ground feldspar some lumps persistently refuse to break up. I have found it very difficult to completely wash the material without some aid of this sort and have experienced no objectionable results from a soft brush.

3. Moisture Content.—Unless otherwise specified the purchase price shall be based on moisture free material and the moisture content shall be determined as follows: 50 grams of the sample (paragraph 1) are carefully weighed out as soon as possible after sampling, and placed in an oven where a temperature between 105°C and 110°C is maintained with proper ventilation till the sample ceases to lose weight, the loss in weight shall be calculated to per cent of the dry weight and so reported.

In case a suitable chemical balance is available the moisture test may be determined on a 5 gram sample.

4. Fusion Behavior.—Test cones of the feldspar shall be made of standard dimensions, *i. e.*, $2^7/_8$ inches high (75 mm.) by $^9/_{16}$ inch (15 mm.) across the base of one face. The use of an organic bond, such as dextrine or gum arabic, is permissible to ensure cones retaining form prior to fusion, but such added material must burn out completely and not affect the color of the fired material. The fusion behavior of the different feldspars shall be as follows for the grade 2 grind.

Grade A Feldspar shall fuse with or before Orton cone 9
Grade B Feldspar shall fuse with or before Orton cone 8
Grade C Feldspar shall fuse between Orton cones 7 and 8
Grade D Feldspar shall fuse with or before Orton cone 7

5. Shipping.—All material purchased under these specifications shall be shipped in clean closed cars.

6. Rejection.—The purchaser reserves the right to reject material which does not conform to the above specifications in every particular and to return rejected material to the vendor for full credit at price charged f.o.b. point of delivery specified by the purchaser.

[1] *Year Book*, AMER. CERAM. SOC., p. 36 (1922–23).

PROPOSED TENTATIVE SPECIFICATIONS COVERING THE PURCHASE OF PULVERIZED FLINT

To Be Used in the Manufacture of Whiteware

1. Sample.—Same as paragraph 1, Feldspar Specifications.[1]

2. Chemical Composition.—The material shall conform to the following limits of chemical composition.

Silica, not less than	99.60%
Potash and Soda, not more than	.15%
Iron Oxides, not more than	.05%
Lime	.10%
Magnesia, not more than	.10%
Alumina, not more than	.10%

Physical Properties and Tests

3a. Color.—The flint when formed into a standard cone and fired in a closed sagger or muffle to a temperature of cone 8 shall have a pure white color both on the surface and the interior and shall be easily broken by the fingers, indicating no fusion.

3b. Fineness of Grain.—One hundred grams of the sample after being dried to constant weight at 105°C shall be tested for fineness of grain by the process set forth in paragraph 2b, Feldspar Specifications, and the residues on the various standard sieves shall not exceed the maximum totals as set forth in the following table.

	Standard Sieve Number					
Grade	100	140	200	270	325	Total residue
1	0.10%	0.2%	1.50	2.00	5	8.8%
2	0.50%	1.0%	2.50	3.50	6.5	14.0

All percentages are calculated on the dry basis.

3c. Moisture Content.—Unless otherwise specified the purchase price shall be based on the moisture free material and the moisture shall be determined as described under paragraph 3, Feldspar Specifications.[2]

3d. Fusion Behavior.—Test cones shall be made of the material according to standard dimensions, *i. e.*, 2 7/8 inches (75 mm.) by 9/16 inch (15 mm.) across the base of one face. An organic bond as dextrine or gum arabic is permissible to insure the cones retaining their form prior to fusion, but such added material must burn out completely and not affect the color of the material. The flint when made into cones as described above shall not deform before cone 24.

3e. Shipping Conditions.—All material purchased under these specifications shall be shipped in clean closed cars.

4. Rejection.—The purchaser reserves the right to reject material which does not conform to the above specifications in every particular and to return rejected material to the vendor for full credit at price charged f.o.b. point of delivery specified by the purchaser.

[1] See p. 163, *This Bulletin.*

[2] *Ibid.*

DISCUSSION ON "SPECIFICATIONS ON FLINT"

H. SPURRIER:—A slight change has been made from the specifications made by Prof. Watts in that the rejections cover the whole shipment rather than a part. It seems an injustice to the shipper to reject part of his shipment and force him to handle the rest at less-than-carload-rates.

F. S. HUNT:—I think that there should be several grades of fineness, and that some grades of flint should not require such fineness of grain.

H. SPURRIER:—That is why two were specified. One is allowed .1% and the other is allowed .5% on 100-mesh. Grade 1 would allow .2% on 140-mesh, and grade 2 would allow 1% on 140-mesh; 200-mesh would be 1.50% for No. 1 and 2.50% for No. 2; 270-mesh would be 2.00% for No. 1 and 3.5% for No. 2; 325-mesh would be 5.0% for No. 1 and 6.5% for No. 2; with a total residue on grade 1 of 8.8% and on grade 2, 14.0%. This composition comes well within the range of published analyses. Some firms offer 99% to 99.9% silica. One company in particular that sells large quantities of flint runs 99.7% and a little over SiO_2 and to put that requirement at 99.5% seems to be well within industrial limits. This protects the consumer from carelessness.

B. E. SALISBURY:—Have any of the flint producers checked this and commented on it?

H. SPURRIER:—No one has seen it since these are only proposed specifications.

B. E. SALISBURY:—I suppose that it is the idea of the Committee to work in collaboration with the raw materials producers. We can set up standards satisfactory to us but they will not mean anything without the consent of the producers. We must have the backing of the raw materials producers or we can make no progress.

H. SPURRIER:—I have a published analysis of a firm producing flint and inasmuch as they have published it and presented it to prospective purchasers it becomes a specification. This producer states that his flint contains 99.8% SiO_2; alumina, .17%; oxide of iron, .104%; lime, 0; magnesia, 0. He offers you 99.8% SiO_2. Others too, offer that high.

F. K. PENCE:—The alumina seems a little low here in the specifications.

H. SPURRIER:—I have other analyses here. Another one shows 99.75% SiO_2; .06% Al_2O_3; commercial flint. This is taken from my private card index which I have kept for a number of years and I have more than one hundred analyses. They are samples offered to the industry and accepted as working material by the producers.

F. K. PENCE:—Alumina is not particularly harmful only as it cuts down the silica content. Much good quality flint will run higher than 11% alumina. In the case of the analysis read by Mr. Spurrier, I know that the concern in question puts out a high grade flint, yet they have an anal-

ysis showing .17% of alumina. This is not serious for it only reduces the SiO_2, but it is not as bad as if it had that much lime or iron. I think that the maximum on alumina might well be raised.

C. C. TREISCHEL:—It might be well to explain the manner in which we intend to proceed with these specifications. They have been referred back to the Division by the divisional Committee on Standards. This Division must recommend to the Standards Committee of the SOCIETY as a whole either the adoption of such a specification or its adoption in a tentative way with certain reservations. We must, however, take action of some sort.

ERIC TURNER:—From the grinders' standpoint, I do not believe that there is anything in particular to live up to. From the producer's standpoint we do not know. We have taken a grade of sand that certain consumers have required.

F. K. PENCE:—We have given two grades on the grinding. We might have another set of specifications on analysis as well.

H. SPURRIER:—I think that it would be entirely proper that we increase the alumina. There is an automatic check there. The presence of Al_2O_3 would imply other things. The SiO_2 would be reduced so as not to come within the specifications. I think the Al_2O_3 should be raised but 99.5% does not seem too exacting.

B. E. SALISBURY:—Would it be feasible to specify the minimum silica content? We might establish limits of impurities, the total of which shall not exceed the difference between the minimum and 100%.

ERIC TURNER:—The specifications for flint seem to be entirely feasible from the producers point of view with one exception. The standard set for the fineness of grain is rather higher than that of the general run of flint marketed to the whiteware trade. In my short experience the average grind of several producers has run a little over 1% (one) residue on a standard 140 test screen. It is not hard to produce flint ground to .2% residue on the above screen but the finer the grind the higher the miller's power bill and therefore the consumer should be expected to pay such a price as would compensate the miller for increased costs.

F. S. HUNT:—I think that it would be well to specify the silica in harmful ingredients but omit the alumina entirely. The silica would take care of that.

H. SPURRIER:—That is similar to the action taken on specifications for other materials. For instance, iron analyses and brass impurities are specified. In similar specifications, in iron or steel, phosphorus is specified. Flint is one thing that we can specify very closely. And I do not think it out of order to keep close watch on the other materials.

F. K. PENCE:—You intend to put them in before alumina?

H. SPURRIER:—Yes.

B. E. SALISBURY:—Mr. Pence, is it the idea to leave the other elements specified. Of those I think that it is highly important to have a limit on the iron oxide at least.

F. K. PENCE:—Iron oxide, .05. What do you think of adopting the other items and leaving the alumina out of it?

H. SPURRIER:—If that means retaining the 99.6%, I am agreed to it.

A motion was made by Mr. Hunt, seconded by Mr. Spurrier and adopted that the proposed specifications for flint stand as given except that under "Chemical Composition" no mention be made of the alumina content.

A motion was then made by Mr. Treischel, seconded by Mr. Salisbury and adopted that the specific action for flint, as amended be adopted by the White Wares Division and recommended to the Standards Committee for action according to the method prescribed by the rules of the SOCIETY.

R. B. LADOO:[1]—The composition of flint as given in the specifications automatically rules out all hydrous or opalescent silicas such as tripoli, diatomaceous earth, true flint, chalcedony, chert, etc., because these materials all contain more or less combined water and do not usually run as high as 99.6% SiO_2. The iron content should be governed by the color of burned test specimens and not by absolute percentage. In other words the method of taking care of the iron content in flint should be the same as that used in the feldspar specifications.

I believe that under composition should be stated only the maximum permissible amounts of harmful impurities such as lime and magnesia, leaving out impurities which are only diluents such as alumina, potash and soda.

I have in mind a hydrous silica tested by a plant ceramist of unquestionable ability and good judgment. This silica had a rather high content of chemically combined water, over 1% alumina and only about 90% silica; yet it was found to be of high grade and perfectly well adapted for the manufacture of the best grades of whiteware.

I do not believe that the flint specifications should be so rigidly drawn as to exclude high grade silica very low in harmful impurities, but which contains much less than 99% SiO_2 due to a high content of combined water and to small amounts of alumina, potash and soda. While it is true that flint is bought for its content of SiO_2 a slightly lower silica content in a hydrous silica might easily be compensated for by a lower price. Aside from harmful impurities such as iron, lime and magnesia the physical properties of the flint should govern and not the chemical properties.

Under paragraph 2, of the Flint Specifications, should be noted the more rapid and efficient method of making sieve tests as described in my discussion, paragraph 2b, in the Feldspar Specifications.

[1] Recd. April 27, 1923.

RECOMMENDED SPECIFICATIONS[1] FOR LIMESTONE, QUICKLIME AND HYDRATED LIME

For Use in the Manufacture of Glass

ABSTRACT

A general description of the use of lime in glass manufacture is followed by definitions of the terms "limestone," "quicklime," and "hydrated lime," and a statement as to the commercial packages in which these materials are marketed.

The quality of lime used in glass manufacture may vary. Any lime containing more than 83 per cent of the oxides of calcium and magnesium is suitable for glass manufacture, provided only that certain particularly deleterious substances are within reasonable limits. The composition should not vary from day to day more than 2 per cent. The material should all pass a No. 16 sieve.

Complete directions for sampling, testing, and retesting are included.

General

1. Use of Lime in Making Glass.—Most common glasses are fused mixtures of alkali (usually soda), alkaline earth (usually lime), and silica. Freedom from color is important in determining the quality of glass, which, in turn, depends upon the absence of coloring oxides (usually iron) from the raw material.

Limestone, quicklime, or hydrated lime may be used for making glass. The decision as to which to use is generally based on availability, cost, and present practice.

2. Definition of Limestone, Quicklime, and Hydrated Lime.—Limestone consists essentially of calcium carbonate, or of calcium and magnesium carbonates where the amount of the latter does not exceed 45.5 per cent. Quicklime is the product resulting from the calcination of limestone and consists essentially of calcium oxide, or of calcium and magnesium oxides. It will slake when water is added to it, and this slaking is accompanied by an evolution of heat and an increase in volume. Hydrated lime is a dry powder which is made by treating quicklime with enough water to satisfy its chemical affinity under the conditions of manufacture. It consists essentially of calcium hydroxide, or of a mixture of calcium hydroxide and magnesium oxide or hydroxide.

3. Packing.—Limestone is shipped in bulk in carload lots, or in cloth or paper bags. Quicklime is shipped either in bulk in carload lots or barrels holding 180 pounds net or 280 pounds net each. Hydrated lime is shipped in paper bags holding 50 pounds net each.

Requirements

1. Quality.—Except for the constituents enumerated below, the composition of a limestone, lime, or hydrated lime may vary within wide limits and still be satisfactory to the glass manufacturer. Either high calcium or high magnesium material may be used. It is essential, however, that the composition be reasonably uniform from day to day. Otherwise the difficulty of controlling the process of manufacture would become too great.

2. Composition.—Quicklime shall not contain more than 3 per cent CO_2 as shipped. Hydrated lime shall not contain more than 5 per cent CO_2 as shipped, and shall contain sufficient water to meet the chemical requirements of the calcium oxide.

Limestones, quicklimes, and hydrated limes may be divided into three classes,

[1] Issued by Department of Commerce, Bureau of Standards, *Circ.* **118,** Dec. 8, 1921.

depending upon the character of glass for which they are suitable. To meet these specifications, the constituents listed below shall not exceed the maximum percentages nor fall below the minimum percentages given in the following table:

TABLE I

COMPOSITION OF THE NON-VOLATILE PORTION OF LIMESTONE, QUICKLIME OR HYDRATED LIME

Ingredients	Class 1		Class 2		Class 3	
	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum
$CaO + MgO$	...	96	...	91	....	83
Fe_2O_3	0.2	..	0.4	..	0.8	..
$SO_3 + P_2O_5$						
(*a*) In Limestone	1.0	..	1.0	..	1.0	..
(*b*) In Quicklime or Hydrated Lime	3.0	..	3.0	..	3.0	..
SiO_2	4.0	..	9.0	..	17.0	..
Al_2O_3	3.0	..	5.0	..	5.0	..

The sum of the calcium and magnesium oxide is specified in the above table. In order to prevent undue variation in the relative proportions of these two ingredients the per cent calcium oxide shall be established by contract, and it is specified that the per cent calcium oxide shall not vary more than 2 per cent either way from the contract figure.

An approximate figure for the content of alumina should also be included in the contract. This figure must come within the limits set in the above table, and it is specified that the amount of alumina in the material delivered shall not vary more than 1 per cent either way from the contract figure.

3. Fineness.—Unless otherwise specified, limestone, quicklime, and hydrated lime shall be crushed so that all will pass a No. 16 sieve.

NOTE.—A No. 16 sieve has an opening of 1.19 mm. and a wire diameter of 0.54 mm., with a permissible tolerance of 2 per cent in the opening and 10 per cent in the wire diameter.

4. Marking.—Each carload of material, or fraction thereof, shall be legibly marked with the names of the consignor and consignee, and with some means of identifying the particular contract on which the shipment is made.

This information is in addition to that required by the Federal lime-barrel law.

5. Retesting.—Notice of the rejection of a shipment based on these specifications must be in the hands of the consignor within 10 days after the receipt of the shipment at the point of destination. If the consignor desires a retest, he shall notify the consignee within 5 days of receipt of the notice of rejection. The consignee shall provide all reasonable facilities to permit the consignor to resample the material. This retest shall be at the expense of the consignor.

Sampling and Testing

1. Sampling.—The purchaser will bear all expense of sampling and testing. When limestone or quicklime is shipped in bulk, the sample shall be so taken that it will represent an average of all parts of the shipment from top to bottom, and shall not contain a disproportionate share of the top and bottom layers, which are most subject to changes. The sample shall consist of 1 shovelful for each 3 tons of material, but not less than 10 shovelfuls, taken from different parts of the shipment. The total sample taken shall weigh at least 100 pounds, shall be mixed thoroughly, and "quartered" to provide

a 15-pound sample for the laboratory. In case a shipment consists of more than one car, a separate sample shall be taken from each car.

When quicklime is shipped in barrels, at least 3 per cent of the number of barrels shall be sampled. They shall be taken from various parts of the shipment, dumped, mixed, and sampled as specified in the above paragraph.

In the case of hydrated lime, the sample shall be a fair average of the shipment. Three per cent of the packages shall be sampled. The sample shall be taken from the surface to the center of the package. The material so obtained shall be thoroughly mixed and quartered to provide a 2-pound sample for the laboratory.

When sampling quicklime or hydrated lime, it is essential that the operation be conducted as expeditiously as possible, in order to avoid undue exposure of the material to the air. The sample to be sent to the laboratory shall immediately be placed in an air-tight container in which the unused portion shall be stored until the shipment has been finally accepted or rejected by the purchaser.

The sample may be taken either at the point of shipment or at the point of destination, as agreed upon by the contracting parties. If it is desired to enforce the requirement as to carbon dioxide, the sample must be taken at the point of shipment.

2. Testing.—The following directions are a brief summary of the analytical methods which are recommended. For more complete information on this subject references should be made to "The Analysis of Silicate and Carbonate Rocks," by W. F. Hillebrand, United States Geological Survey, Bulletin No. 700.

Blast 0.5 g. of the sample for 15 minutes in a platinum crucible. Cool and transfer to an evaporating dish. Mix to a slurry with distilled water. Add 5 to 10 cc. concentrated HCl. Heat gently until solution is complete, breaking up lumps if necessary. Evaporate to dryness on water bath. Add 5 to 10 cc. concentrated HCl and dilute with an equal volume of distilled water. Digest on water bath for 10 minutes. Filter and wash with hot water. Evaporate the filtrate to dryness. Dissolve in acid and water as before. Filter, and wash with hot water. Ignite the two precipitates together and weigh as silica and insoluble matter.

Dilute the above filtrate to 250 cc. Add HCl if necessary to insure a total volume of 10 to 15 cc. Make alkaline with NH_4OH. Boil until odor of NH_3 is barely noticeable. Filter, and wash slightly with hot water. Dissolve the precipitate with hot dilute HCl and repeat the precipitation as before. Filter and wash thoroughly with hot water. Ignite and weigh as oxides of iron, aluminum, and phosphorus.

To the filtrates from the above add a few drops of NH_4OH and bring to a boil. Add 25 cc. of a saturated solution of $(NH_4)_2C_2O_4$. Continue boiling until the precipitate becomes granular. Let stand until precipitate settles clear. Filter, and wash with boiling water. Ignite the precipitate, dissolve in dilute HCl, and dilute to 100 cc. Add excess of NH_4OH, and boil. Filter out any insoluble matter, ignite and weigh, and add its weight to the oxides of iron and aluminum found previously. To this filtrate add $(NH_4)_2C_2O_4$, proceeding as before. Filter, and wash with boiling water. Ignite, and blast to constant weight as calcium oxide.

Acidify the filtrates from the above with HCl. Evaporate to 150 cc. Add 10 cc. of a saturated solution of $NaNH_4HPO_4$ and boil. Cool. Add NH_4OH drop by drop, with constant stirring, until the precipitate starts to form. Then add moderate excess of NH_4OH. Stir for several minutes. Let stand over night. Filter, and dissolve the precipitate in hot dilute HCl. Dilute to 100 cc., add 1 cc. of saturated solution of $NaNH_4HPO_4$, and precipitate as before. Filter, and wash with an alkaline solution made by diluting NH_4OH until it contains about 2.5 per cent NH_3 and then add a few drops of HNO_3. Ignite, and weigh as $Mg_2P_2O_7$. Multiply this weight by 0.3621 to find the weight of MgO.

Place 5 g. of the sample of quicklime or hydrated lime, or 0.5 g. of limestone, in a small Erlenmeyer flask and cover with hot distilled water. Connect this flask into a carbon-dioxide train, set up as follows: Next to the flask is a reflux condenser, to which is connected a calcium-chloride drying tube, followed by a tube containing anhydrous $CuSO_4$, then another tube of $CaCl_2$, then by two tubes filled with soda lime, and finally by another tube of $CaCl_2$. The entire train must be so arranged that a stream of CO_2 free air can be kept passing through it. Start this stream of air. Weigh the tubes containing soda lime and replace them in the train. Add to the sample in the flask about 25 cc. of 1:1 HCl, being careful that no gas is lost and that the effervescence is not too violent during the operation. When the effervescence diminishes, heat the flask, bringing the liquid gradually to boiling. Boil for 10 minutes. Remove the flame and allow the flask to cool while the stream of air is still flowing, for 15 minutes. Disconnect and weigh the soda-lime tubes. Their increase in weight is recorded as carbon dioxide.

Dissolve 5 g. of the sample in HCl and evaporate to dryness. Dissolve the residue in HCl, filter, and wash with hot water. Fuse the residue with Na_2CO_3. Treat the filtrate with NaOH in boiling solution, filter, and wash with hot water. Dissolve both this precipitate and the fused residue in dilute H_2SO_4. Reduce with Zn and titrate with $\frac{N}{20}$ $KMnO_4$. Calculate the result to per cent Fe_2O_3.

Dissolve 2 g. of the sample in 10 cc. water and 15 cc. 1:1 HCl. Filter out insoluble matter. Dilute filtrate to 250 cc. Heat to boiling and add 10 cc. of a boiling 10 per cent solution of $BaCl_2$, drop by drop, with constant stirring. Let stand over night, filter, wash with hot water, ignite, and weigh as $BaSO_4$. Calculate to per cent SO_3.

Dissolve 10 g. of the sample in 80 cc. of 1:1 HNO_3. Filter, wash, fuse the residue with Na_2CO_3, dissolve the melt in HNO_3, and add this solution to the filtrate. Boil the filtrate with 10 cc. of 1.5 per cent $KMnO_4$ solution until MnO_2 is precipitated. Add enough H_2SO_3 to dissolve the MnO_2. Neutralize with NH_4OH. Add 1 cc. of concentrated HNO_3 for every 100 cc. of solution. Bring to 40°C and precipitate with ammonium molybdate. Shake for 10 minutes and let stand at 40°C for 12 hours. Filter and wash with 1 per cent KNO_3. Dissolve the precipitate in a known volume of $\frac{N}{10}$ NaOH and CO_2 free water. Titrate the excess NaOH, using phenolphthalein as indicator. Calculate the per cent P_2O_5, using the proportion, P: NaOH = 1: 23.

SUGGESTED SPECIFICATIONS FOR CERAMIC WHITING[1]

A. General

1. Definition of Ceramic Whiting.—Ceramic whiting is a finely ground white powder composed of nearly pure calcium carbonate or calcium carbonate and magnesium carbonate obtained from pulverizing and sizing chalk, marble or limestone, or as a chemically precipitated product.

2. Use of Whiting in Ceramic Products.—Whiting is used to furnish the calcium oxide component of glazes, enamels, and fluxed ceramic bodies. It is an active fluxing agent, rarely used in large quantities in body mixtures. It may be either used as a raw ingredient in glazes, or fritted or smelted with other glaze materials before application.

[1] Revised April 7, 1923.

3. Packing.—Whiting is packed and shipped in barrels holding not more than 325 pounds or bags holding not more than 125 pounds. The package should be labeled stating whether the contents is a natural rock whiting or a chemically precipitated whiting.

B. Requirements

1. Quality.—Whiting shall be uniform in quality (from shipment to shipment), both as to fineness of grain and composition. The calcium, magnesium, or total carbonates shall not vary more than ±1% and the silica not more than ±1/2 of 1% of a figure set by contract within the limits of the composition shown in Class 1 or Class 2. It should be manufactured from the purest rock available and should be free from particles of pyrites, iron-bearing silicates, metallic iron and gypsum.

2. Composition.—Whitings shall be divided into two classes, No. 1 being practically a pure calcium carbonate and No. 2 containing calcium carbonate with a considerable percentage of magnesium carbonate within the limits of the composition given. This does not indicate that one class is inferior in quality to the other, but indicates that numerous users prefer the magnesium whiting to the pure calcium whiting.

CLASS 1

Material	Total carbonates	$CaCO_3$	$MgCO_3$	Fe_2O_3	SiO_2	SO_3
Maximum.....	..	..	1%	0.25%	2.0%	0.1%
Minimum.....	97%	96%	...	....	...	...

CLASS 2

Material	Total carbonates	$CaCO_3$	$MgCO_3$	Fe_2O_3	SiO_2	SO_3
Maximum.....	..	..	8%	0.25%	2.0%	0.1%
Minimum.....	97%	89%	..	....	...	...

3. Fineness.—Screening samples by washing for ten minutes with stream of water practically without pressure shall not leave a residue of more than 1% on a No. 140 screen (or more than 2% on a No. 200 screen), and at least 98% of the material shall pass a No. 200 screen. It shall also be so fine that a separation made by a Pearson[1] air separator will show at least 85% of the material finer than .02 mm. and at least 48% finer than .01 mm.

As an alternative to the Pearson air separator method the following (not so desirable) may be used: 2 1/2 gms. of the material shall be shaken for ten minutes in a 250 cc. cylindrical graduate with 250 cc. of distilled water. On allowing to settle it shall require not less than 20 minutes for visible settling to cease when the cylinder is viewed in reflected light, using clear north sky light for illumination.

4. Marking.—Each shipment of material shall be legibly marked with the names of consignor and consignee and with some means of identifying the particular contract on which the shipment is made.

5. Retesting.—Notice of the rejection of a shipment based on these specifications must be in the hands of the consignor within 10 days after the receipt of the shipment at the point of destination. If the consignor desires a retest, he shall notify the consignee within five (5) days of receipt of said notice.

[1] The Pearson air separator developed at the Bureau of Standards by J. C. Pearson and F. A. Hitchcock gives excellent separations of fine dry powders and is the only machine which can be used for this purpose for particles as small as .01 mm. Its use is therefore recommended for manufacturers and users of fine powder such as whiting, flint, feldspar, paint pigments, etc.

C. Sampling and Testing

1. Twenty-five per cent of the number of packages shall be selected for sampling.—A core representing the contents of each of these packages shall be taken with a sampling tube. The total material so collected shall weigh not less than 5 lbs. This shall be thoroughly mixed and quartered to provide a $^1/_2$-lb. sample for the laboratory.

2. Testing.—The following directions are a brief summary of the analytical methods which are recommended. For more complete information on this subject references should be made to "The Analysis of Silicate and Carbonate Rocks," by W. F. Hillebrand, United States Geological Survey, Bulletin No. 700.

Blast 0.5 g. of the sample for 15 minutes in a platinum crucible. Cool and transfer to an evaporating dish. Mix to a slurry with distilled water. Add 5 to 10 cc. concentrated HCl. Heat gently until solution is complete, breaking up lumps if necessary. Evaporate to dryness on water bath. Add 15 cc. concentrated HCl and dilute with an equal volume of distilled water. Digest on water bath for 10 minutes. Filter and wash with hot water. Evaporate the filtrate to dryness. Dissolve in acid and water as before. Filter and wash with hot water. Ignite the two precipitates together and weigh as silica and insoluble matter.

Dilute the above filtrate to 250 cc. Make alkaline with NH_4OH. Boil until odor of NH_3 is barely noticeable. Filter and wash slightly with hot water. Dissolve the precipitate with hot dilute HCl and repeat the precipitation as before. Filter and wash thoroughly with hot water. Ignite and weigh as oxides of iron, aluminum and phosphorus.

To the filtrates from the above add a few drops of NH_4OH and bring to a boil. Add 25 cc. of a saturated solution of $(NH_4)_2C_2O_4$. Continue boiling until the precipitate becomes granular. Let stand one hour. Filter and wash with hot water. Ignite the precipitate, dissolve in dilute HCl, and dilute to 100 cc. Add excess of NH_4OH and boil. Filter out any insoluble matter, ignite and weigh and add its weight to the oxides of iron and aluminum found previously. To this filtrate add $(NH_4)_2C_2O_4$, proceeding as before. Filter, and wash with boiling water. Ignite, and blast to constant weight as calcium oxide.

Acidify the filtrates from the above with HCl. Add 10 cc. of a saturated solution of $NaNH_4HPO_4$ and evaporate to 150 cc. Cool. Add NH_4OH drop by drop with constant stirring until the precipitate starts to form. Then add moderate excess of NH_4OH. Stir for several minutes. Let stand over night. Filter and dissolve the precipitate in hot dilute HCl.

Dilute to 100 cc., add 1 cc. of saturated solution of $NaNH_4HPO_4$ and precipitate as before. Filter and wash with dilute NH_4OH (25% NH_3 containing a few drops of HNO_3). Ignite and weigh as Mg_2P_2O. Multiply this weight by 0.3621 to find the weight of MgO.

Place 0.5 g. of the sample in a small Erlenmeyer flask and cover with hot distilled water. Connect this flask into a carbon-dioxide train, set up as follows: Next to the flask is a reflux condenser, to which is connected a calcium-chloride drying tube followed by a tube containing anhydrous $CuSO_4$, then another tube of $CaCl_2$, then by two tubes filled with soda lime, and finally by another tube of $CaCl_2$. The entire train must be so arranged that a stream of CO_2 free air can be kept passing through it. Start this stream of air. Weigh the tubes containing soda lime and replace them in the train. Add to the sample in the flask about 25 cc. of 1:1 HCl, being careful that no gas is lost and that the effervescence is not too violent during the operation. When the effervescence diminishes, heat the flask, bringing the liquid gradually to boiling. Boil for 10 minutes. Remove the flame and allow the flask to cool while the stream of air is still

flowing, for 15 minutes. Disconnect and weigh the soda lime tubes. Their increase in weight is recorded as carbon dioxide.

To five grams of the sample in a covered vessel, add 25 cc. of water, and then cautiously 10 cc. of concentrated hydrochloric acid. Break up any lumps with the flattened end of a glass rod and boil for 2 or 3 minuts. (1) Reduce the hot solution with a few drops of stannous chloride solution, cool, dilute to 100 cc., add 10 cc. of mercuric chloride solution, and titrate with standard potassium dichromate solution ($N/20$), using potassium ferricyanide as outside indicator. Calculate the results to Fe_2O_3. A blank determination is desirable for comparison.

The permanganate method for determination of total iron, as given by Blair in "The Chemical Analysis of Iron," may also be used.

Fuse 2.5 g. of the sample with about 10 g. of sodium carbonate, and dissolve the melt in 10% hydrochloric acid. (Any insoluble residue should be filtered off and tested by flame test for barium. If barium is absent, the residue may be rejected; if present, the residue should be again fused with an excess of sodium carbonate, and the water extract tested for SO_3.) Dilute the clear solution to 250 cc. heat to boiling and add slowly 10 cc. of hot 10% solution of barium chloride. Formation of a white precipitate indicates the presence of sulfur. A blank test should be made to insure the purity of reagents used.

(1) For extremely accurate work any insoluble matter may be filtered off at this point, ignited, fused with sodium carbonate, and the melt dissolved in 10% hydrochloric acid and added to the filtrate.

DISCUSSION ON "SPECIFICATIONS ON WHITING"

LED BY H. H. SORTWELL

SECRETARY C. C. TREISCHEL:—The departments at Washington are very much interested in this specification but they want to get the final action from the AMERICAN CERAMIC SOCIETY before proceeding further with it.

H. H. SORTWELL:—Last year Mr. Williams, of the Bureau of Standards, made a study of a good many different brands of whiting which were on the market. Samples were collected from different users and from the results of those tests they wrote these specifications. The definition of whiting is:

> Whiting is a finely ground white powder composed of nearly pure calcium carbonate obtained from pulverizing and screening chalk, marble or limestone, or as a chemically precipitated product.

That gives a wide range in the source of materials which may be used. The general requirements are:

1. Quality: Whiting shall be uniform in quality (from shipment to shipment), both as to fineness of grain and composition. The carbonates shall not vary more than —1% and the silica not more than —$^1/_2$ of 1% of a figure set by the contract within the limits of the composition shown under (*b*). It should be manufactured from the purest material available and should be free from pyrites, iron-bearing silicates, metallic iron, and gypsum.

2. Composition.—Whiting shall have the following limitations in composition:

Material	Total Carbonates	CaCO	$MgCO_3$	Fe_2O_3	SiO_2
Maximum	.....	...	2%	0.2%	4.0%
Minimum	95%	95%	...	...	...

B. E. SALISBURY:—What do the analyses of the commercial firms show as to $CaCO_3$?

CHAIRMAN F. K. PENCE:—I have a criticism of that specification. Here are some analyses: English cliffstone whiting SiO_2 out of analyses of four representative samples gave the silicate content slightly less than 1%. Another sample gave slightly in excess, 1.6%. I believe that 4% silica is too high. On domestic whitings analyses of four different samples from four different sources show silica contents of 1.28, 1.1, 1.03 and another one of 3.7%. Two per cent seems plenty high enough since even the last 3.7% is too high.

B. E. SALISBURY:—Does that agree with the calcium content?

F. K. PENCE:—No, there is another on that. I think that the magnesia is too low. English cliffstone will show 1.1% but domestic runs as high as from 5 to 7%. Many of these domestic whitings are perfectly good for industrial use. Hence I would criticize this specification on these two points.

H. SPURRIER:—I agree in regard to the silica content. I have a number of analyses here. The first one is: Water, 0.16, carbon dioxide, 42.72; iron oxide and alumina, 0.61; lime, 53.44 (pure whiting would be 56%); silica, 2.09; magnesia, 0.08%. The magnesia is exceptionally low. Domestic materials run higher than that. However, in glaze making I think the magnesia content of 5% would be rather disturbing because of its important function. It usually increases the fluidity of the glaze in small amounts but its presence in larger amount decreases the fluidity. We ought to keep our magnesia reasonably low, but we might tolerate more than 0.08%. It should be about 2% maximum, as carbonate.

B. E. SALISBURY:—That would bar a number of producers of whiting. At the same time it would save much trouble.

H. SPURRIER:—That is what I have in mind. There are two things to consider: the buying and selling factors. Our own industry is the one that gives importance to these things and in regard to disturbing factors, the potters have enough to cope with. It is very difficult to operate a plant and get something constant if laboratory equipment is lacking. There is an urgent need for specifications or rather classification. Most of these things start out of the natural line, and you can't do very much. The process of manufacture doesn't improve from the point of view of composition. The final condition is improved, but since decisions have to be made more rapidly than the analyses, we ought to be able to place some

reliance on the goods. In the past we have had very little of that kind of assurance.

B. E. SALISBURY:—It seems to have been brought out that there are some kinds of work for which the domestic whiting is satisfactory. Could this not be handled like flint, by having two grades of whiting?

E. TURNER:—This method would be satisfactory if the gradation was not more than a certain amount. The magnesia should not vary more than one-half of one per cent. from what they figure.

F. K. PENCE:—These specifications have provided for that. There seems to be a general consensus of opinion that 4% is too high for the silica content. I believe that 2% has been mentioned as the proper amount. Does anyone want to make a motion amending that portion of the specification?

B. E. SALISBURY:—I make that motion.

H. SPURRIER:—I second it.

C. E. JACKSON:—The Bureau of Standards never prepares any specifications that have not been drawn up with the full consent and advice of the producers. That specification has already come from the producers.

H. SPURRIER:—Some of these analyses show what the producers offer.

F. K. PENCE:—In chemical analyses there is seldom more than 2% of silica in either domestic or English whitings. That is too much in my opinion.

H. SPURRIER:—In one dozen analyses I have found but one whiting showing 3%. In my card index, covering a good many years there is only one showing 3%. Analyses which run higher do so from other reasons.

H. H. SORTWELL:—Might it not be a good idea to have two separate silica classifications?

P. H. BATES:—Then you are up against classifications and not specifications.

H. SPURRIER:—That probably is the final conclusion. You can classify, but not specify. Nature has done that for you.

F. K. PENCE:—As indicated by analyses from many different sources, it does not appear that 2% is unreasonable for silica content. We are ready to vote on the motions that we set the silica at not more than 2%.

The motion was put and carried that the silica content requirement of the specifications for whiting be set at not more than 2%.

F. K. PENCE:—It is questioned as to whether 2% is not too low a limit to place on the magnesia content. It is satisfactory for English cliffstone whiting but it would eliminate domestic whitings.

B. E. SALISBURY:—For purposes of discussion I move that we establish two classifications on whiting, Number 1 and Number 2.

F. K. PENCE:—May we have suggestions as to the limit?

C. E. JACKSON:—Magnesia, 5%.

F. S. HUNT:—Eight per cent.

F. K. PENCE:—I have 5.11, 7.23, 6.27, 6.21, 6.22.

A. V. BLEININGER:—These might be raised. If amounts of 5 or 6% do not do any harm I should be in favor of raising the magnesia content. I think that the limit of 5 to 6% would be satisfactory.

F. K. PENCE:—Most of the analyses on the domestics run over that amount.

A. V. BLEININGER:—Some of them run below that, but to be definite we might say 6% for magnesium carbonate.

H. SPURRIER:—The following analysis was made of waste material from the Solvay Process Company of Detroit. The silica was 1.62, magnesia (MgO), 4.77. This was made from the limestone of the Sibley Quarry near Detroit, which is partly dolomitic; $MgCO_3$, 9%; SO_3, .05%, that is, the sulphuric acid was originally sulphate. The lime ran 50 as CaO.

F. S. HUNT:—I do not believe that you can set a second classification at 6% unless you make a third at 8%.

F. K. PENCE:—It seems to me that you would have to include them in No. 2. No. 1 is going to eliminate them. It seems to me that you might as well let them in as to get within a per cent of it and cut them out.

C. E. JACKSON:—No. 2 gives a good range, but it will fill only a certain field. If we include all of the American whitings in No. 2, it would be their privilege to have a high magnesium.

It was moved by Mr. Jackson, seconded by Mr. Salisbury and adopted that the specifications for whiting be amended to include two classes, one with a magnesium content of 6% and the other with a magnesium content of 8%.

F. K. PENCE:—The iron content is all right, I believe. The analyses on English cliffstones show: .27, .263, .19, .196; domestic: .182, .204, .219; .2 seems quite close.

H. H. SORTWELL:—I think these figures were set from the results of analyses which were made from those samples examined at the Bureau of Standards. If .2 is considered too low, it might be all right to raise it to .25. That would match very well with the analyses already given.

F. K. PENCE:—I find there is some discrepancy in the iron content in whiting for this reason: In analyzing whiting it is dissolved in acid and the iron determination is made on solution. What remains is insoluble residue. If the two are put together it frequently runs over .2%.

H. SPURRIER:—A great many analyses are made where the iron oxide and alumina are together. For pottery purposes it is essential that the Fe_2O_3 is known. Very few manufacturers want to wait for analyses.

F. K. PENCE:—That is true. Mr. Mueller, what figure do you usually get out of the insoluble residue?

H. C. MUELLER:—For Fe_2O_3, I believe .3 of 1% could be used.

F. K. PENCE:—Do you recall whether you get .05 or .1 on the iron in the insoluble residue?

H. C. MUELLER:—One-tenth.

B. E. SALISBURY:—It is quite evident if the analyses you have on the best grade of whiting procurable run from .2 of 1% that it would be unwise to run over that on specifications.

F. K. PENCE:—I think that it is too close. In ground cliffstone rock there is more than .2 iron. There is no way of washing the iron from limestone rocks laid down by nature. Twenty-five hundredths is more reasonable and some are more than that.

H. C. MUELLER:—I know of one which was reported by the company which gave an Fe_2O_3 content of .14 of a per cent and English whiting usually runs .22 or .23. This was reported as .14.

F. K. PENCE:—It actually was as high as .22. We thought the difference was from the insoluble residue.

It was moved by Mr. Salisbury, seconded by Mr. Jackson and adopted that the iron content of whiting in the specifications be set at not more than .25%.

H. H. SORTWELL:—The proposed specification for fineness is as follows:

Fineness: Screening samples by washing for ten minutes with a stream of water practically without pressure shall not leave a residue of more than 1% on a No. 140 screen (or more than 2% on a No. 200 screen) and at least 98% of the material shall pass a No. 200 screen. It shall also be so fine that a Pearson air separator will show at least 85% of the material finer than .02 mm. and at least 48% finer than .01 mm.

In comparing these whitings there was a difference in grain fineness that would not be shown in sieves up to 200-mesh. The rest of the specification simply describes the details of sampling and testing the material. If these limits for fineness are satisfactory the points are all covered.

B. E. SALISBURY:—I should like to see a requirement that the producer shall put on his invoice and his container whether or not the whiting is precipitated.

This motion was approved by common consent.

G. SIMCOE:—I should like to suggest the point that the sulphur present indicates the presence of gypsum and this causes a great deal of trouble. The carbonates go off at a lower temperature when bodies are open and the gas escapes. The sulphates go off at a higher temperature when bodies are viscous producing pimples.

H. H. SORTWELL:—The specification states that if there were any considerable amount of sulphur the material would be rejected.

F. K. PENCE:—The point which covers that is under number 2*a* which says "It should be manufactured from the purest materials available and should be free from iron-bearing silicates, pyrites, metallic iron and gypsum. On the other hand we specify the iron content.

I. E. SPROAT:—Under 2*b* it also says: "The qualitative test described below shall indicate the absence of sulphur."

F. K. PENCE:—According to this, there should be no sulphur at all.

G. SIMCOE:—But it should be guaranteed.

B. E. SALISBURY:—That could be put under the impurities.

H. SPURRIER:—I have no actual data on this, but I have never found any sulphur. The qualitative test finds a heavy trace of some. But this point is very important.

F. K. PENCE:—I suppose this can be referred to the Committee and let them find out what it ought to be. Does anybody have any suggestion as to what limit should be stated in chemical analysis for sulphur?

C. E. JACKSON:—Preferably zero.

The use of whiting or Paris white for Ceramic purposes has been handed down to American potters largely by the English. The source of English whiting is the chalk cliffs of England. The whiting or Paris white made from these cliffs is remarkably pure and possesses physical properties peculiar to itself.

The uniformity of its chemical composition makes it the standard material and any whiting or Paris white should be compared with this material and classified accordingly. I suggest a specification defining the ideal chemical composition then placing a limitation on the permissible variation of any whiting or Paris white not coming within the limits being classed as a No. 2 whiting or Paris white.

Furthermore, the term whiting should not be used in Ceramic Literature unless whiting is desired. Whiting is made from the soft weathered English Cliffstone rock, while Paris white is made from the hard unweathered rock and is considered by English potters the better material for pottery purposes. Samples of the crude rock weathered and unweathered show quite a different physical structure. The unweathered rock would seem to be more uniform.

I. E. SPROAT:—I think whiting containing sulphur ought to be rejected.

F. K. PENCE:—I think the best way is to put this up to the Committee on Standards so that we can have something more than a general statement. There is some sulphur present but if we are running into a slug of gypsum we ought to be able to determine in these specifications a way to exclude it. By common consent we will incorporate into our instructions a definite limit on sulphur.

It was moved by Mr. Salisbury, seconded by Mr. Jackson and adopted that the specifications for whiting, as amended, be adopted by the White Wares Division and recommended to the Standards Committee for action according to the method prescribed by the rules of the SOCIETY.

A. E. WILLIAMS:—The Interdepartmental Conference Committee on Chemical Lime greatly appreciated the discussion of the whiting specifications, and the additional information and checking of figures against factory experience should make these specifications satisfactory and useful.

In accordance with the discussion, the specifications have been changed so that the maximum silica content is now only 2%, the allowable iron content 0.25%, and a figure for sulphur is provided allowing 0.1%.

The situation with regard to magnesium is slightly uncertain in that the motion adopted as recorded by the stenographer provides for two classes of whiting, one containing 6% and another 8% MgO. But judging from the context of the discussion, we are assuming that there are two classes intended, one a high calcium whiting allowing 2% of MgO, and another a dolomitic whiting allowing 8% MgO as a maximum. These maximums, together with the tolerances placed on the contents of CaO and MgO from shipment to shipment from any one dealer should provide a uniform raw material.

The revised specifications are attached herewith and further discussion is encouraged.

PROPOSED TENTATIVE SPECIFICATIONS FOR SILICA SAND FOR GLASS-MAKING

The specifications for limestone, burnt lime and hydrated lime presented to the Division last year have been handed to the Standards Committee of the SOCIETY to obtain approval of the SOCIETY. This specification has been slightly modified, allowing 3.0% of SO_3 and P_2O_5 in burnt and hydrated limes, this being because of the use of fuels containing sulphur in burning the stone.

The following is the tentative specification for glass sands submitted by the Committee for discussion. These specifications have been prepared by Committee on Standards of the Glass Section in coöperation with the Bureau of Standards.

General

(1) **Character of Sand.**—Sand as commonly used for glass-making purposes is a white, clean, dry, fine-grained quartz, washed practically free from all clay-like material and other impurities. The chief criterion for a good glass sand is that it should be practically all silica and contain very little iron.

In view of the increasing use of alumina in a glass batch and of the varying amounts of iron allowable in green or amber glass, sand of lower grade may be used by many manufacturers. These specifications, therefore, will show a variety of qualities and state more or less definitely the types of glass they may be used for. The quality number is not to be interpreted as necessarily being an index to value of the product.

Requirements

2. Packing.—Cars in which sand is to be shipped shall be thoroughly cleaned before loading, and lined with paper where sand is sold for first, second or third quality.

3. Impurities.—Sand shall not be contaminated with stripping dirt or contain any crushed stones or pebbles. These impurities are often insoluble in the melting glass, producing stones.

4. Screening and Washing.—All sand shall be screened, washed and dried before shipment, except where the natural condition of the quarries will allow the production by screening only of fourth, fifth, sixth or seventh quality sand.

TABLE I

PERCENTAGE COMPOSITION OF SANDS OF VARIOUS QUALITIES (BASED ON IGNITED SAMPLES)

Qualities	SiO_2 Max.	SiO_2 Min.	Al_2O_3 Max.	Al_2O_3 Min.	Fe_2O_3 Max.	Fe_2O_3 Min.	CaO + MgO Max.	CaO + MgO Min.
First quality optical glass	99.8		0.1		.02		0.1	
Second quality flint glass containers tableware	98.5		0.5		.035		0.2	
Third quality flint glass	95.0		4.0		.035		0.5	
Fourth quality sheet glass rolled and polished plate	98.5		0.5		.06		0.5	
Fifth quality sheet glass rolled and polished plate	95.0		4.0		.06		0.5	
Sixth quality green glass containers and window glass	98.0		0.5		0.3		0.5	
Seventh quality green glass	95.0		4.0		0.3		0.5	
Eighth quality amber glass containers	98.0		0.5		1.0		0.5	
Ninth quality amber	95.0		4.0		1.0		0.5	

5. Although sand may vary considerably in composition, depending on the type of glass to be made, the composition of any single quality specified shall not vary from shipment to shipment more than the amounts stated in Table II.

TABLE II

PERCENTAGE TOLERANCES IN COMPOSITION ALLOWED (BASED ON IGNITED SAMPLE)

Quality	SiO_2	Al_2O_3	Fe_2O_3	CaO + MgO	Rmx
1	±0.1%	±.05%	+0.005%	±0.05%	
2	±0.5	±0.1	+0.005	±0.05	
3	±1.0	±0.5	+0.005	±0.1	
4	±0.5	±0.1	+0.005	±0.1	
5	±1.0	±0.5	+0.005	±0.1	
6	±1.0	±0.5	±0.05	±0.1	
7	±1.0	±0.5	±0.05	±0.1	
8	±1.0	±0.5	±0.1	±0.1	
9	±1.0	±0.5	±0.1	±0.1	

6. Sand shall be prepared so that the size of grains shall be rather uniform and be within the limits set in Table III:

TABLE III

LIMITING PER CENTS OF VARIOUS SIZES OF SAND GRAINS

Through a No. 20 screen	100%
Through a No. 20 and remaining on a No. 40 screen	Not more than 60% nor less than 40%
Through a No. 40 and remaining on a No. 60 screen	Not more than 40% nor less than 30%
Through a No. 60 and remaining on a No. 100 screen	Not more than 20% nor less than 10%
Through a No. 100 screen	Not more than 5%

Methods of Testing

Screen tests shall be made with sand dried to 110°C, using United States Bureau of Standards standard screen sizes.

Methods of Analysis

To determine silica, lime and alumina, follow methods given in Hillebrand's Rock Analysis, U. S. G. S., Bulletin No. 700.

Iron may be determined by any of the following methods:

Colorimetric Method of Iron with Sulphocyanate.

Scott's Standard Methods of Chemical Analyses (*Bull.* **3**(1907)), page 222.

Electrometric Titration.

Stokes & Cain Method (Bureau of Standards).

The following method may be used for solution of the sands for any method of determining iron:

.5 gm. sample. Fuse in Pt crucible with four times wt. of pure Na_2CO_3. Dissolve in 200 cc. warm H_2O (warm on steam bath). Dilute 15 cc. of conc. HCl to 50 cc. Add this from a burette slowly, drop by drop to the solution, stirring frequently and keeping solution cold to prevent silica from separating out. The acid having been added, add a small amount of pure Zn (.05 gm.) to solution to precipitate out any Pt dissolved in the carbonate fusion. When Zn has dissolved, filter the solution into a 500-cc. graduated flask and proceed.

ACTIVITIES OF THE SOCIETY

WE ARE GROWING EVERY DAY IN EVERY WAY BIGGER, BETTER AND MORE EFFECTIVE IN SERVICE TO CERAMIC INDUSTRIES

The score board for the 1923 membership committee is as follows in net totals at each of the dates of record.

	Personal	Corporation	Total	Net gain by months
January 12	1571	213	1784	
March 14	1710	223	1933	149 (2 months)
April 14	1738	226	1964	31
May 14	1775	233	2008	44
Total net gain	204	20	224	

The record of the individual score getters during the fiscal month of April 15th–May 14th is as follows.

	Personal	Corporation		Personal	Corporation
R. K. Hursh		1	A. Malinovszky	1	
Howard Frost		1	C. W. Parmelee	1	
Charles W. Crane		1	Robert C. Rahn	1	
Frederick H. Rhead	2		Herman Reinbold	1	
R. R. Shively	2		Louis E. Rodgers	1	
A. S. Watts	2		S. Satoh	1	
D. F. Albery	1		J. B. Shaw	1	
E. E. Ayars	1		Alexander Silverman	1	
L. E. Barringer	1		Gaylord T. Stowe	1	
Arthur B. De Vol	1		E. W. Tillotson	1	
J. F. Greene	1		W. W. Wilkins	1	
Frank M. Hartford	1		W. G. Whitford	1	
Seiji Kondo	1		Office	12	4

Total 37 Personal
7 Corporation

The passing of the 2000 membership mark is noteworthy—but only in the passing. Two thousand members never was the goal, in fact the possible roster of ceramists whose industrial welfare is served by the SOCIETY is many times two thousand. When passing the 2000 membership mark the SOCIETY is merely starting on its way.

NEW MEMBERS RECEIVED FROM APRIL 15 TO MAY 14

PERSONAL

Agazim, Michael, 365 E. Illinois St., Chicago, Ill., Salesman, Wishnick-Tumpeer Chemical Co.

Booth, William K., 737 Addison St., Chicago, Ill., The Booth Electric Furnace Co., Secy. and Chief Engineer.

Brooks, John W., Avery and Whittier Aves., Syracuse, N. Y., Secy.-Treas., Pass and Seymour, Inc., Solvay, N. Y.

Carlstrum, C. G., 503 Perry Payne Bldg., Cleveland, Ohio, Manager, Refractory Products Company.

Cahoon, Chester P., 42 S. Main St., Salt Lake City, Utah.

Denison, Geo. W., 8829 Broadway, Cleveland, Ohio, Vice-Pres. and Gen. Manager, The Ohio Clay Company.

Drever, Horace, 908 Chestnut St., Philadelphia, Pa., Electrical Engineer, Manufacturing-Electric Furnace Construction Co.

Du Bois, Hassell Burton, Alfred, N. Y., Student, Alfred University.

Facer, Charles A., 1242 Oak Grove Ave., Steubenville, Ohio, Decorator and Designer, H. Northwood and Co.

Fick, Clarence W., General Electric Company, Schenectady, N. Y., Engineer in Power and Mining Department.

Galvin, Grover H., Rockford, Ia., Vice-Pres. and Gen. Mgr., Rockford Brick and Tile Co.

Gosser, George W., 438 S. 4th St., Coshocton, Ohio, Ass't Supt., Pope-Gosser China Co.

Grady, George Morrill, 74 Pacemont Rd., Columbus, Ohio, Student, O. S. U., Columbus.

Fuwa, Kitsuzo, 589 Araijiku Iriarai-Machi, Ebara-Gun Tokyo-Fu, Japan, Engineer, Tokyo Electric Co.

Hilgenberg, Carl G., % Carr Lowrey Glass Co., Fairmont, W. Va., President.

Hill, W. H., Murphysboro, Ill., President, Murphysboro Paving Brick Co.

Hoduker, W., Dipl. Ingenieur, Tlmenan, Thüringen, Germany.

Jackson, Will F., Olivet, Mich., Bird Artist.

Koyama, I., Technical College at Keijo, Korea, Japan.

Krause, Ellis L., 218 Fifth St., Marietta, Ohio, Prof. of Chemistry, Marietta College.

Lewis, J. H., Van Briggle Tile and Pottery Co., Colorado Springs, Colo., Secy. and Treas.

Marvel, P. A., Croze Bldg., Philadelphia, Pa., The Vitrifax Co.

Morton, William A., 1317 Fulton Bldg., Pittsburgh, Pa., President, Amsler-Morton Co., Inc.

Prowell, Harry D., 726 S. Hope St., Los Angeles, Cal., Pyrometer Engineer, Adolf Frese Corpn.

Pumphrey, M. E., 40 Rector St., N. Y. City, Salesman, General Refractories Co.

Rafter, Michael Joseph, 728 Plum St., Vineland, N. J., Manager, Kimble Glass Co.

Reinbold, Herman, 103 S. 18th St., Omaha, Neb., Pres., Reinbold Metallurgical Co.

Riddick, James W., Jr., 4702 Lexington St., Chicago, Ill., Methods Engineer, Western Electric Co., Hawthorn Sta.

Senn, William E., 808 W. Adams St., Sandusky, Ohio, Student, O. S. U.

Sondles, Merrill A., 421 S. 7th St., Coshocton, Ohio, Statistical Engineer, Pope-Gosser China Co.

Smith, Geo. O., Carr Lowrey Glass Co., Baltimore, Md., Chemist and Glassmaker.

Starr, C. D., 116 Point St., Providence, R. 1., Supt., Rehoboth Porcelain Enamel Co.

Stein, Chas. M., 48 rue de la Boëtic, Paris, France, Fuel Engineer.

Trostel, Louis J., 103 Buell Ave., Joliet, Ill., Chief Chemist, American Refractories Co.

Wells, J. M., Newell, W. Va., Treas., American Potteries Co.

Yamuzawa, Itsuo, Nihon Chitsuso Hilyō Co., Minamatama-chi, Ashikitagumi, Kumamoto Ken, Japan.

Zimmer, W. H., Waldershof, Bavaria, Johann Haviland Porzellanfabirk.

CORPORATION

Armstrong Cork and Insulation Co., Pittsburgh, Pa., N. B. Gates, Pres.

Crossman Company, South Amboy, N. J., Charles W. Crane, Pres.

Illinois-Pacific Glass Co., Fifteenth and Folsom Sts., San Francisco, Cal., Otto Rosenstein, Vice-Pres.

Jointless Fire Brick Co., 1130 Clay St., Chicago, Illinois, Albert Goetz, Treas.

Olean Tile Company, Olean, N. Y., Gordon Phillips.

Pacific Clay Products Co., Los Angeles, Cal., E. M. Durant, Pres.

Weir Stove Co., Taunton, Mass., J. L. Anthony, Pres.

WHO'S WHERE IN THE AMERICAN CERAMIC SOCIETY

A. E. Acheson has changed his address to 19 Kensington Ave., Jersey City, N. J.

Walter O. Amsler, formerly president of the Amsler-Morton Co., of Pittsburgh is now with the Owens Bottle Factory–1, 982 Wall St., Toledo, Ohio.

E. E. Ayars is living at 702 Jasper St., Joliet, Ill.

M. C. Booze of Mellon Institute has moved to Thackery and O'Hara Sts., Pittsburgh.

R. C. Brett has notified the Secretary's office that his address is 1697 Lee Road, Cleveland Road, Cleveland Heights, Ohio.

James E. Brinckerhoff, formerly of East Liverpool, Ohio, with the Babcock and Wilcox Co., has removed to 95 Liberty St., N. Y. City with the same company.

M. L. Bryan is now with the Columbia Terra Cotta Co., Box 788, Vancouver, Wash.

Dorothy Peck Chapman who has been living at East Orange, N. J., has moved to 23 Carolina Road, Montclair, N. J.

E. V. Coulston has left the Rock Island Stove Co., at Rock Island, Ill., and is living at 1265 E. 55th St., Cleveland, Ohio.

S. F. Cox has moved from Haverhill St., to 1011 Coal St., Wilkinsburgh, Pa.

T. W. Garve is now living at Brazil, Ind., 106 E. Compton St.

Marsden H. Hunt of the Western Electric Co., has moved from San Francisco to 62nd and Green Sts., Emeryville, Cal.

G. G. Kent formerly of the Detroit-Star Grinding Co., is now with the Square D Co., Peru, Ind.

H. J. Knollman of Philadelphia recently accepted a position with the Pacific Clay Products Co., at Los Angeles, Cal.

Chas. E. Kraus has changed his address to 110 W. 40th St., New York City.

R. B. Ladoo has resigned from the Bureau of Mines, Washington, D. C. and has an office with the newly formed Southern Minerals Corporation at 901 Continental Bldg., 14th and H Sts., N. W., Washington, D. C.

Percival Marson of Edinburgh, Scotland is now technical superintendant and chemist with Messrs. Sowerby's Ellison Glass Works, Ltd., Gateshead-on-Tyne, England.

G. Z. Minton is living at 1221 S. Anderson St., Elwood, Ind.

D. M. Moodie has removed from Norwood, N. Car., to 1225 Hamlet St., Columbus, Ohio.

Joseph K. Moore formerly of 120 Broadway, N. Y. City is now at 11 Broadway.

The Pacific Clay Products Company is located at 600 American Bank Bldg., 129 W. Second St., Los Angeles, Cal.

F. K. Pence has moved from East Liverpool, Ohio to Paducah, Ky., where he is located with the Paducah Tile and Pottery Co., as President.

Amos Potts is with the Franklin Brick and Tile Co., 8 East Long St., Columbus, Ohio.

Walter S. Primley, president of the Wisconsin Granite Co., has moved his office in Chicago, Ill. from W. Washington St., to 105 West Monroe St.

Louis E. Rodgers of the L. E. Rodgers Engineering Co., formerly of Chicago has moved to the Central Life Bldg., Ottawa, Ill.

John E. Sachs is living at 1221½ Main St., Evansville, Ind.

H. H. Sortwell who has been with the Bureau of Standards at Washington, D. C. is now with the Star Porcelain Co., Trenton, N. J.

Harry Spurrier has left the Square D. Co., at Peru, Ind., to accept a position with the Northwestern Terra Cotta Co., Chicago, Ill.

A. H. Stewart, formerly of Mellon Institute is now with the Phoenix Glass Co., at Monaca, Pa.

C. A. Underwood has changed his address to the General Refractories Co., 40 Rector St., New York City.

Jack H. Waggoner has moved from Topeka, Kans., to Charleston, W. Va., where he is located with the Libbey-Owens Sheet Glass Co.

Thomas C. Walker, Jr., is working for the Central of Georgia Railway at the Ceramic Experiment Station, Columbus, Ohio. Mr. Walker was formerly with the Matewan Tile Co., Matewan, N. J.

S. Paul Ward recently of the Shasta Zinc and Copper Co., Winthrop, Cal. is now with the Nevada Consolidated Copper Co., McGill, Nevada.

Word has been received that **Pittsburgh High Voltage Insulator Co.**, of Derry, Pa. has been changed to the **Westinghouse High Voltage Insulating Company.**

ELEVATION TO ACTIVE MEMBERSHIP

The Board of Trustees has acted favorably on the promotion from Associate to Active membership. These were nominated by the active members of the SOCIETY.

ASSOCIATES NOMINATED TO ACTIVE MEMBERSHIP

Edward Anderson, Supt., The A. A. Simonds Co., Dayton, Ohio
Cecil E. Bales, Louisville Fire Brick Wks., Highland Park, Ky.
Ralph F. Brenner, H. C. Fry Glass Co., Rochester, Pa.
Alfred E. Blake, 928 Union Arcade, Pittsburgh, Pa.
A. Lee Bennett, U. S. Bur. of Mines, Seattle, Washington
Lawrence H. Brown, Edwin M. Knowles Co., Newell, W. Va.
Dr. E. N. Bunting, 203 Ceramics Bldg., U. of I., Urbana, Ill.
John Clark, 292 Lockwood St., Astoria, N. Y., N. Y. Architectural Terra Cotta Co.
B. F. Drakenfeld, Jr., Treas., Drakenfeld Co., So. Murray St., New York
Frederic W. Donahoe, Secy., Refractory Mfgrs. Assoc., 840 Oliver Bldg., Pittsburgh, Pa.
Walter Geer, Jr., N. Y. Architectural Terra Cotta Co., 401 Vernon Ave., Long Island City, N. Y.
T. D. Hartshorn, U. S. Bur. of Standards, Kensington, Md.
James O. Handy, Pittsburgh Testing Lab., Box 1115, Pittsburgh, Pa.
H. S. Hower, Carnegie Institute of Tech., Pittsburgh, Pa.
R. F. Harrington, 388 Dorchester Ave., S. Boston, Mass., Hunt-Spiller Mfg. Corp.
R. F. Ferguson, Mellon Institute, Pittsburgh, Pa.
Herbert I. Insley, U. S. Bur. of Standards, Washington, D. C.
Paul S. MacMichael, Northern Clay Co., Auburn, Wash.
W. J. Rees, Lecturer and Head of Research Dept. in Refractories, Univ. of Sheffield, Ranmoor, Sheffield, England
Dr. S. R. Scholes, Federal Glass Co., Columbus, Ohio
Geo. E. Sladek, Beaver Falls Art Tile Co., Beaver Falls, Pa.
L. E. Saunders, Mgr. Research & Abrasive Plants, Norton Co., Worcester, Mass.
J. M. Stangl, Factory Mgr. Fulper Pottery Co., Flemington, N. J.
Gus M. Tucker, N. Y. Architectural Terra Cotta Co., 401 Vernon Ave., Long Island City, N. Y.
C. A. Underwood, Amer. Refractories Co., 120 Broadway, N. Y. City.
Dr. R. R. Shively, Chief Technologist, B. F. Drakenfeld & Co., New York

AMENDMENTS TO CONSTITUTION

All the amendments to the Constitution and By-Laws as published in advance in April *Bulletin*, page 86, received the necessary affirmative votes hence they are now operative.

For the nomination of Trustee Representatives of the Divisions it shall be necessary for each member who wishes to vote to declare which of the Divisions shall be known as his Major Division. A member can vote on Trustee representative only in that Division which he shall declare to be his Major. This declaration of Major Division membership will not affect one's membership in any of the other Divisions nor his vote on any question other than nomination of Trustee Representatives except as shall be described in the rules adopted by the Divisions themselves.

CONVENTIONS OF THE SOCIETY

Summer Meeting.—Details of the summer meeting in August have not been worked down to a definite program but this much is known. The Detroit Section with Frank H. Riddle leading is planning to give a royal welcome and a profitable time to those of the SOCIETY who will be their guests, August 8, 9, 10 and 11.

Glass and enamel products, spark plugs, grinding wheels, wall tile brick, indeed a large variety of ceramic plants and a large number of other industrial plants such as the automobile factories will be visited.

Most pleasant lake and river excursions are planned.

A more profitable week and excursion could not be planned than with fellow ceramists in the Detroit district.

The profit and pleasure is as much from the fellowship and broadened acquaintances as from the plants visited.

The 1924 Annual Convention.—Atlantic City, February 4, 5, 6, is the place and time.

The New Jersey Clay Workers' Association and Eastern Section of the AMERICAN CERAMIC SOCIETY of which Andrew Foltz is president, will be the hosts.

Hotel Traymore will be the headquarters.

Plans are already in the making for unusual plant trips on Thursday, Friday and Saturday of the Convention week.

CONTRIBUTION TO NEW CERAMIC SCHOOL

Mr. A. F. Greaves-Walker, President of the AMERICAN CERAMIC SOCIETY, has secured an important donation of equipment for the new school of Ceramics at the Georgia School of Technology, Atlanta, Ga. The contribution from the J. C. STEEL AND SONS CO., was secured by personal solicitation by Mr. Greaves-Walker and consists of one of their No. 3 Combined Brick and Tile Machines (20–30 M capacity) and a Hand Cutter for both brick and tile. The SOCIETY wishes to express its appreciation to this firm for their part in the organization of this new school of ceramic engineering.

OBITUARY

John J. Herold, late superintendent of the Ohio Pottery Company, died at his home in Zanesville on Wednesday, April 18. He had been in poor health for a number of years, and had not been active in business for several months.

Herold was born in 1871 in Carlsbad, Austria. He received his primary education locally and attended various art schools. He went through the usual period of apprenticeship and became a decorator on china and glass. As he was not in sympathy with the military domination of that time, he came to this country about twenty-eight years ago.

He worked in various glass factories in the East and came to Zanesville where he worked in the local art potteries, later becoming superintendent of the Roseville Pottery, a position which he held until 1908 when he went to Golden, Colorado on account of his health.

He built a small pottery, experimented with local clays and raw materials and developed and produced chemical porcelain ware, a product which is in considerable use in this country, but which before 1914 came from Germany, then the principal source of supply.

The Herold China Company was organized, and this company now operating as the Coors Porcelain Company practically enjoys the monopoly of the chemical porcelain industry in this country at the present time.

Herold was essentially a potter and not a business man. Consequently he was throughout his career more or less a victim of those who preferred to take advantage of his lack of business experience rather than capitalize on the full possibilities of his practical knowledge and at the same time give him a fair acknowledgment in return.

He left the Golden concern which he founded and organized and came to Cambridge, Ohio, where he produced chemical porcelain wares for the Guernsey Earthenware Company, and later was one of the founders and the superintendent of the Ohio Pottery Company where chemical porcelain, cooking wares and later porcelain dinner wares were produced.

Herold's work in Colorado was remarkable for the fact that he explored the mountains of the district for clays and raw materials, afterwards using these in his products. His first equipment was very primitive, and operated with little or no assistance except that of his brother-in-law who was not a potter.

He had little means, consequently his difficulties will be appreciated by those who know the conditions involved, especially when it is remembered that he was in poor health and not expected to live for a considerable period.

Besides his work on high temperature porcelain, Herold developed and produced a number of bodies and glazes of considerable industrial value. He was a sincere and earnest technical student and followed closely the German technical literature of the day. His main contribution to the Art Ware industry is possibly his development of the copper red glaze, a glaze better known to connoisseurs as the Chinese ox-blood or Rouge Flambe. This glaze, as its name implies, is a brilliant blood-red and can only be obtained by the reduction of copper, a process in the present state of ceramic practice involving a consumate knowledge of kiln operation and manipulation.

Herold was without doubt one of the greatest practical potters of the day. The fact that his activities were mainly concerned with industrial activities of ordinary size does not diminish the importance of his accomplishments in the minds of those who have closely followed his work.

It is to be regretted that he never had the opportunity of working with those who could either appreciate him to his full value, or who could adequately create conditions where he could work to the best of his ability.

For the purely personal side, he was both modest and unassuming so far as his accomplishments were concerned, but he possessed a commanding and forceful personality, characteristics which coupled with his knowledge and experience enabled him to direct the production of widely varying types of ceramic wares under most unfavor-

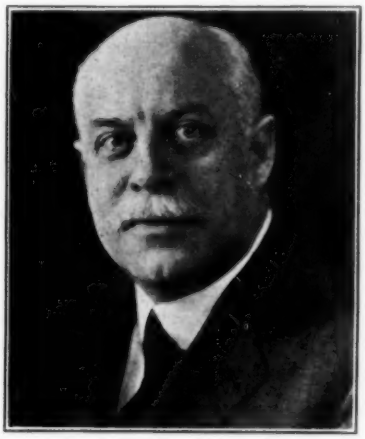
able conditions, and more often than not with the help of comparatively unskilled labor.

He was a fine, fearless and upright character and was loved by all who knew him. His passing is a great loss to the industry.

NOTES AND NEWS

DR. GEORGE K. BURGESS: NEW DIRECTOR OF THE BUREAU OF STANDARDS

The President has appointed Dr. George K. Burgess to the Directorship of the National Bureau of Standards. The appointment is a happy one, for Dr. Burgess is the outstanding member of the staff both with respect to his scientific attainments, his successful administration of the Division of Metallurgy, and the large and helpful contact which he has established with the industries. Dr. Burgess is of old New England stock. He was educated in the public schools of Newton, Massachusetts, the Massachusetts Institute of Technology, and the University of Paris. The latter institution conferred on him the degree of Doctor of Science, with highest mention. He was successively assistant in Harvard College Observatory, instructor in physics at the University of Michigan and at the University of California. In 1903, he was appointed Assistant Physicist in the Bureau of Standards. His work in pyrometry was notable and his published work on the laws of radiation and their application to high temperature measurements laid the scientific foundation for pyrometry as applied in American industry.



DR. GEORGE K. BURGESS.

In 1913, Dr. Burgess was made Chief of the Division of Metallurgy. His organization and program are models of scientific research organization. His published work includes some 75 titles and covers such important fields as railway materials, metals and metallurgy, high temperature measurements, general physics and science, and the organization of scientific and technical research. He has served as expert on many national and international commissions, and is an active member of the technical committees of numerous national societies. At the present time he is President of the American Society for Testing Materials.

VOLUNTARY ADOPTION OF STANDARDS OF QUALITY

BY JULIUS H. BANNER[1]

Among numerous topics of interest to the members of the Chamber of Commerce of the United States contained in the Annual Report of Secretary of Commerce Hoover for the year 1922, there is one to which I particularly desire to invite your attention. Under the heading "Voluntary Establishment of Grades and Qualities" Secretary Hoover has the following to say:

[1] President, U. S. Chamber of Commerce.

"Agitation has been current for many years for the extension of the Federal laws to the establishment of grades and qualities of different commodities. The lack of such established grades and standards of quality adds very largely to the cost of distribution because of the necessity of buying and selling upon sample or otherwise, and because of the risk of fraud and misrepresentation, and consequently the larger margins in trading. It was considered by the department, however, that it would be infinitely better if such grades and qualities could be established voluntarily in the trades themselves instead of by legislation, and policed by trade associations as is the case in several old established trades. To this end a number of conferences have been held in different branches of the lumber, textile, paper, and other trades. The service of the department has been to bring the different branches of the trade, the manufacturers, wholesalers, retailers, and representatives of larger consumers' associations together and to develop committees of different branches of trades. The plan has been generally welcomed and applications have been received from many trades for such assistance. The expert services of the Bureau of Standards, Bureau of Foreign and Domestic Commerce, and the other bureaus of the department have been brought into service for technical advice in these matters, and results of important bearing upon the improvement of business ethics and cheapening of distribution have been attained."

Voluntary Action Preferable to Legislation

This topic of voluntary action of business men to establish definite grades for various lines of merchandise should be of especial interest to the organization of the National Chamber. Shoe manufacturers, textile manufacturers, and others have been worried by snap-judgment proposals to set up so-called "pure shoe" and "pure fabric," etc., standards by government action. Of course, the reputable American business man is not afraid or unwilling to sell his goods on reasonably drawn specifications or to stand back of the quality of his product to a reasonable extent. There is nobody better qualified to pass on what is and what is not reasonable as a standard of quality or performance than those who are in the trade itself. Here, as Secretary Hoover points out, is undoubtedly a field for voluntary action on the part of producers, manufacturers, and merchants in establishing grades and setting standards of quality or performance, with which the consumers will be sympathetic.

Quality Standards Cut Down Commercial Disputes

Business is facilitated and the ground for commercial disputes between buyer and seller is narrowed down if sales are made on the basis of standard grades of merchandise, perfectly familiar to both buyer and seller. This is a phase of business of particular importance in international transactions, where different trade practices and different conditions exist. In a good many foreign countries there has been loss of good will for particular American dealers as well as some lingering prejudice to the good name of American business generally, which can be traced to the lack of understanding and agreement between buyer and seller as to the qualities entering into transactions, or to the absence of standards of quality and performance. When such standards exist, backed up by the moral force of a trade association or trade group in the United States, the promotion of the sale of American merchandise of a given kind and the building of good will toward American trade abroad are made easier, and rest upon a sound foundation.

Many Commodities Already Sold on Standard Qualities

There are a good many commodities sold extensively in the foreign trade for which quality standards commonly understood and accepted here and abroad are in effect,

either as a result of government action or as a result of voluntary action by the trade. The following commodities are exported largely on the basis of such quality standards: Grains—including wheat, oats, corn, barley, rye, rice, kafir, etc.; cotton, cottonseed products and other oil products and by-products; tobacco; coal; petroleum products; lumber; fertilizers; flour; meats and provisions; preserved and salt fish; fresh and dried fruits; canned goods; food specialties and drugs. In the year 1921 these commodities alone totaled in value about $2,700,000,000, or nearly two-thirds of the total export trade of the United States. In addition, copper and other metals, cement, various chemicals, iron and steel products, and a whole range of engineering material, and other commodities shipped abroad in considerable volume are sold on the basis of known specifications or known standards of quality and performance.

Important in Domestic as Well as Foreign Trade

I want to call this subject directly to the attention of the chambers of commerce, and the trade associations—especially the latter—in the membership of the National Chamber. Standardization, and the setting up of systems of inspection and certification in some cases, have made most progress among lines of raw material and food stuffs sold in bulk and moved in large amounts. The full possibilities of doing business on standards of quality have not yet been realized, even in many such lines of merchandise. It is, of course, not only in the foreign trade, but in the whole wide range of domestic trade that the use of clear standards, easily checked up, may be developed. The American Society for Testing Materials, and many other organizations represented in the American Engineering Standards Committee are making great progress in setting up and improving national standards on engineering products. The applicability of the same principles to numerous lines of manufactured specialties is well worthy of consideration by trade associations and chambers of commerce.

Opportunity for Action by Associations

In lines of merchandise where conditions warrant the adoption by representative trade associations of certain definite standards of quality or performance, the associations can hold to account any member failing to make delivery up to the standards adopted, and incorporated in sales contracts. Disputes arising in connection with such transactions readily lend themselves to settlement by the parties themselves, or by commercial arbitration.

Inspection Facilities

Some commercial and trade associations not only set up standards, but go further and provide rules and facilities for inspection and certification of merchandise. Costs must be kept down. With all due recognition of this fact, however, where actual inspection and certification of individual shipments do not add disproportionately to the costs of merchandise, and do serve a useful purpose, associations may well consider the possible desirability of making some arrangements, either with existing bureaus, laboratories, or other agencies doing commercial work of sampling, inspecting, testing, and certifying, or of actually setting up such accommodations if they do not exist adequately for the needs of the particular industries as those needs grow.

Coöperation by Government and Chamber

A good many association executives, and a good many manufacturers who at first have been skeptical of the possibility of setting standards in their particular lines, have gone to Washington and sat in with the members of the Federal Specifications Board,

and participated in the drafting of workable specifications for all federal government purchases in their lines. In the case of some commodities the federal specifications thus adopted are actually becoming used in private trade. The Bureau of Standards of the Department of Commerce has at all times shown a disposition to go as far as it can with the business men in working out technical specifications. There are laboratory and testing facilities here, provided by the tax payer, which may be availed of for this purpose. The director of the Bureau of Foreign and Domestic Commerce, of the Department of Commerce, has expressed the willingness of the chiefs of the commodity divisions in that Bureau to work with associations in this matter of standards of quality, particularly as they bear on the foreign trade. Our Department Managers in the different departments of the staff of the Chamber of Commerce of the United States are desirous of coöperating with any organization undertaking or extending this class of work.

NOTES FROM THE BUREAU OF STANDARDS

Service Tests of China Tableware

The Bureau of Standards has arranged for a series of service tests of hotel china at several prominent hotels. The tests have already been started at the Biltmore Hotel in New York and will be commenced at other places in the near future. Samples of the plates tested will be sent to the Bureau for laboratory examination, and large lots of the same ware will be put in service and examined from time to time in order to correlate the service given by the plates with the laboratory results.

Meeting of the Committee of the Federal Specifications Board on China and Glassware

The Federal Specifications Board's committee on china and glassware, at a meeting on March 26, adopted a list of sizes and shapes of chinaware and glassware which was accepted by all members of the committee. The resulting list shows a very considerable cut in the variety of sizes and shapes besides being definite and simple, and it will be used in obtaining bids. Drawings of all these articles have already been made and exhibited to all members of the Potters' Association so as to make certain that the articles adopted as standard are made by practically all manufacturers of this type of ware. It so happens that the potters are arranging a standard list of hotel ware in which only those articles are enumerated which are made by all potters for hotel and railroad service. The list adopted by the committee is similar to the list which the potters expect to adopt with very few exceptions.

A meeting will be held next month of potters, hotel buyers, representatives of the Pullman Company, and the Federal Specifications Board for the purpose of agreeing upon a final list.

Coefficient of Expansion of Glass Pots

The relation between the coefficient of expansion of the material from which the glass pots are made and that of the glass is an important matter, since it influences the cracking of either the pots or glass or both during cooling. During the month, the Bureau of Standards has measured the coefficient of expansion of three pieces of glass pot bodies, two being of the same composition but cooled in different ways while the third was of another composition. The values show a uniform increase from 0° to 700°C (the

limit of the test) of about 0.04 micron per cm. per degree Centigrade which is much less than the corresponding value for borosilicate glass, this value being 0.1 micron. Therefore, the only explanation for the tendency of borosilicate glass to break in pots, even with slow cooling, is that the relative strength of the glass is less than that of the pot.

ANNOUNCEMENT: THE NATIONAL TERRA COTTA SOCIETY

At the Annual Meeting of the National Terra Cotta Society at Atlantic City, N. J. April 21st, 1923, Mr. E. V. Eskesen, President of the New Jersey Terra Cotta Company, was elected President of the Society for the ensuing year. The remaining officers are: Mr. O. W. Ketcham, First Vice-President, Mr. Adolph Hottinger, Second Vice-President, Mr. Walter Geer, Jr., Treasurer and Mr. F. S. Laurence, Executive Secretary.

Mr. Eskesen was knighted by the King of Denmark April 30th, 1923, being decorated with the Order of Danebrog in recognition of his services in promoting the common interests of the Danish-American peoples, especially in the interchange of university scholarships, etc. between the two countries.

PRIZE FOR NEW IDEA

Members of the AMERICAN CERAMIC SOCIETY will be interested in noting the offer of a prize of $50.00 by the Vitreous Enameling Company of Cleveland for a *new idea* for an enameled product. Suggestions are to be sent to the Company on or before July 1, 1923, and the winner will later be announced in the pages of the *Bulletin*. Full details of this announcement are to be found among the advertisements of this issue of the *Journal*.

CALENDAR OF CONVENTIONS

AMERICAN CERAMIC SOCIETY (ANNUAL MEETING)—ATLANTIC CITY, FEB. 4, 5 AND 6, 1924.

AMERICAN CERAMIC SOCIETY (SUMMER MEETING)—TOLEDO, DETROIT AND VICINITY, AUGUST 8, 9, 10 AND 11, 1923.

American Chemical Society—Chemists' Club, N. Y. City, June 8.

American Dental Trade Association—Spring Lake, N. J., June.

American Electroplaters' Society—Providence, R. I., July 2–5.

American Face Brick Association—First Week in December.

American Face Brick Association (Southern Group)—West Baden, Ind., November.

American Gas Association—Atlantic City, Week of Oct. 15.

American Institute of Chemical Engineers—Wilmington, Del., June 20–23.

American Society for Testing Materials—Chalfonte-Haddon Hall Hotel, Atlantic City, June 25, 1923.

Clay Products Association—Chicago, Ill., Third Tuesday in each month.

Dental Manufacturers' Club of the U. S.—Spring Lake, N. J., June, 1923.

Fire Underwriters' Association of the Northwest—Chicago, Ill., October 17–18.

Manufacturing Chemists' Association—New York, June.

National Association of Window Glass Manufacturers—Place and date not determined.

National Exposition of Chemical Industries—New York, Sept. 17–22.

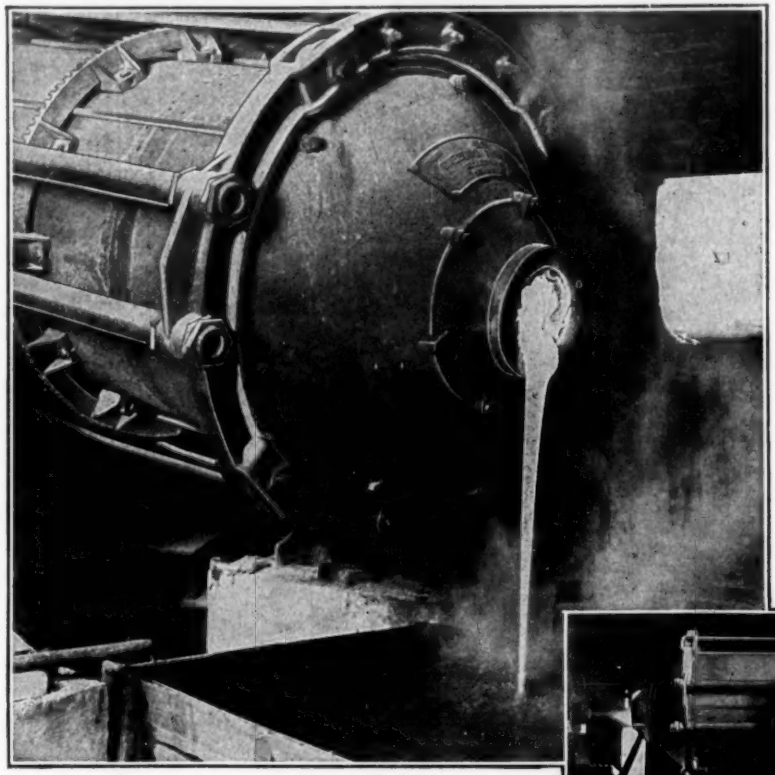
National Lime Association—Hotel Commodore, New York City, June 13–15.

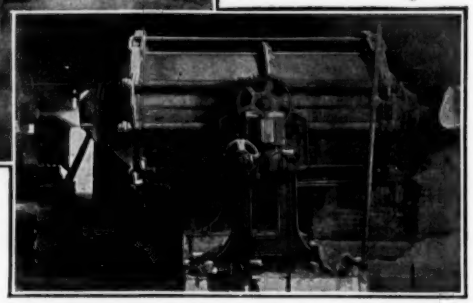
National Symposium on Colloid Chemistry—University of Wisconsin, June 12–15.

Sanitary Potters' Association—Pittsburgh, Pa., Monthly Meetings.

Society for Steel Treatment (Eastern Section)—Bethlehem, Pa., June 14 and 15, 1923.

Tile Manufacturers' Credit Association—Beaver Falls, Pa., Quarterly Meetings.





These illustrations made from photographs taken in the plant of Ingram-Richardson Mfg. Co., Beaver Falls, Pa

12-21

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Let the U. S. Furnace melt your enamel.

Write for specifications and prices on 60 lb., 150 lb., 400 lb., 750 lb., and 1200 lb. Enamel Furnaces. We will send photographs and list of users where furnaces are in operation.

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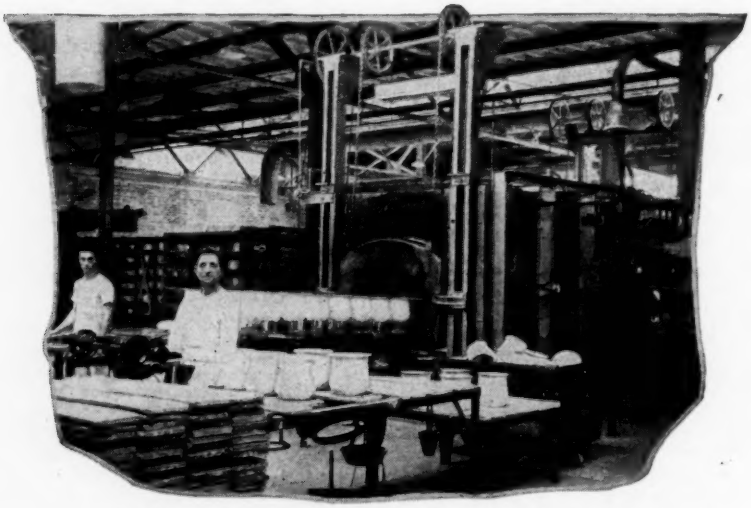

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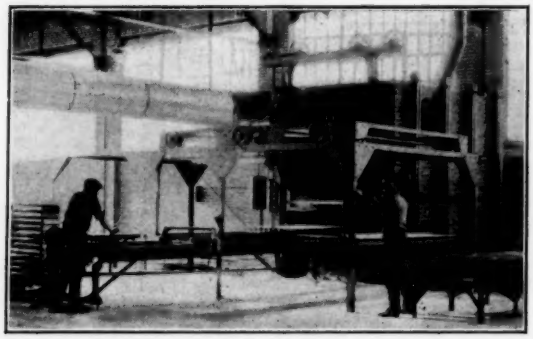

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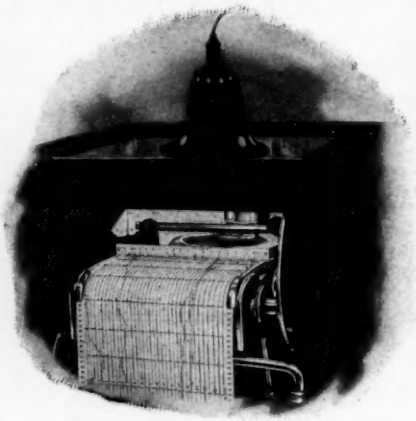

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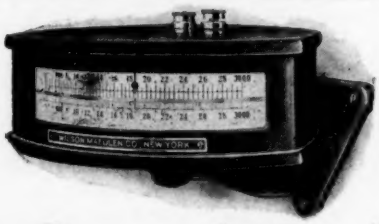

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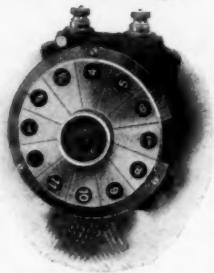

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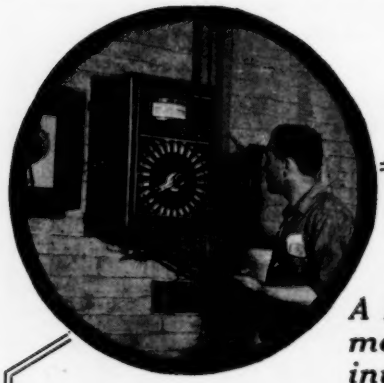

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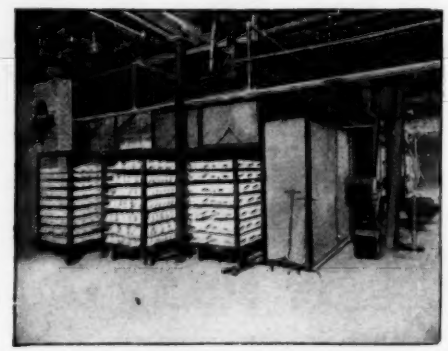

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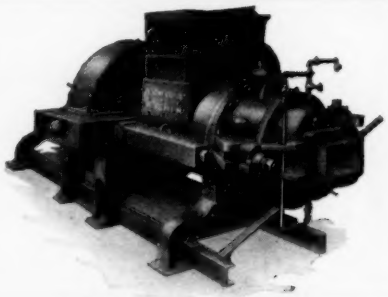

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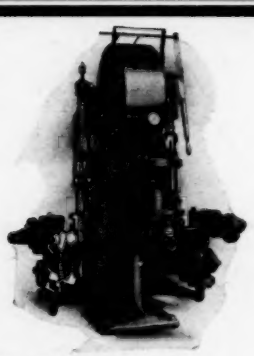

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